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AUTHOR Baird, William E.
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ABSTRACT

The purpose of this training module is to introduce science teachers at the secondary level to effective applications of microcomputers for instruction and to provide information on the current state of science-related microcomputer courseware. Designed to provide for 12 presentation hours, the module is divided into seven sessions: (1) Realities and Aspirations; (2) Computer-Assisted Instruction and Computer-Managed Instruction (CAI and CMI); (3) Simulations, Tutorials, and the Use of Graphics; (4) Calculations, Analysis, and Workup of Data; (5) Collections of Experimental Data; (6) Problem Solving Strategies and Inquiry; and (7) Conclusions and Evaluation. The four sections of this document provide: (1) a rationale for the subject matter, an overview of the entire module, and suggestions for presentation; (2) notes for the presenter, including step-by-step procedures for organizing major concepts into sequential sections with overview, learner outcomes, lists of needed materials and equipment, and time requirements for each of the seven sessions; (3) materials for participants, including all of the handouts needed to present the entire training module; (4) instructional materials, including a short description of a videotape intended for use with the sixth session, and transparency masters and diskettes needed for presenting the module. The appendixes include a list of science courseware, useful addresses and sources of assistance, a certificate to be handed out to participants, and a listing of all of the programs on each of the diskettes intended for use with this module. (EW)

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INTERACT

Microcomputers in Secondary Science

William E. Baird

IR013708

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Education Service Center
Region XIII
7703 N. Lamar
Austin, Texas 78752
512-458-9131

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PROJECT STAFF

Joe Parks, Executive Director

Donroy Hafner, Director,
Division of Instructional Services

Gloria McClanahan, Consultant

Wallace Mills, Consultant

Susan Pennington, Consultant

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Preface

The format of this training module consists of five, tab divided sections consisting of the following:

Introduction. The introduction contains information from both the authors and the project staff of the training module. This information gives a rationale for the subject matter, an overview of the entire moduel, and suggestions for presentation.

Presenter's Notes. Step by step procedures for major concepts are organized into sequential sessions with overview, learner outcomes, lists of needed materials and equipment and time requirements for each session.

Participant's Materials. All the handouts needed to present the entire training module are included in this one section to facilitate the duplication process. If only portions of this module are to be given, applicable handouts should be pulled for reproduction.

Instructional Materials. A short description of the location of the video tape included with this module is given. Transparencies must be created from the transparency masters in this section. Also included in this section are the following diskettes needed for presenting this module:

Dreyfus Institute Diskette #1
J & S Demo-X
Vernier, Ray Tracer
BSCS Volume II
Dreyfus Institute Diskette #4
Dreyfus Institue Diskette #2
Vernier, Graphical Analysis
HRM Experiments in Science Demonstration Diskette

The producers of these diskettes have graciously allowed the duplication of them for training purposes. It is the responsibility of each presenter to insure that these diskettes are used for training purposes only and that no indiscriminate copying occurs as such abuse would eliminate the availability of such software for any future training needs.

Publishers Catalogs are contained in the supplementary packet, also.

To present this module effectively, some software not included in this training module should be obtained by the presenter. That software may be available at regional service centers or may be borrowed from vendors or science teachers. That software includes:

Sunburst's SemCalc
HRM's Experiment in Science kit
McGraw Hill's Geology Search

Appendices. Included in this section of the module are lists of science courseware, useful addresses and sources of assistance, a certificate to be handed out to the participants if desired, and a listing of all the programs on each of the diskettes included with this module. This information may or may not be reproduce for distribution to the participants of any workshop.

This training module was prepared with much care and enthusiasm by its author and its project staff. We hope that it will fulfill its intended purpose, to assist teachers to realize specific applications of computer technology to the science curriculum. If any questions develop concerning the materials or the use of those materials in this training module, please contact ESC XIII staff or its author, William E. Baird, Science Education Center, EDB 340, University of Texas, Austin, Texas 78712.

We would be delighted to hear how the training module is used and whether it succeeded in its purpose.

Introduction

The explosive growth of microcomputers in secondary schools throughout Texas and the nation has been well documented. According to a survey done by Johns Hopkins University, 85 percent of all U.S. high schools had one or more microcomputers for instruction by January, 1983. Between June, 1982 and January, 1983, nearly half of secondary schools which had not previously owned a microcomputer acquired one.

Although use varies with local school priorities and teacher interests, more and more of these new additions to the classroom are being utilized by science teachers. Here the types of uses depend on the hardware limitations and advantages of the microcomputers available, the software written for each machine, funds accessible for purchase of courseware and peripheral attachments, and the background and training of teachers in each school. The type and quality of information available to teachers is also critical in determining how well microcomputers are utilized for instruction. Where teachers are unaware of good software available for their grade level, subject matter area, and type of microcomputer, it is not surprising that they may not make full use of computers in their teaching. Teachers who have never seen laboratory data collected and plotted graphically by microcomputers are unlikely to appreciate that potential function for the new machines. Similarly, teachers who have never witnessed a good simulation program present interactive science situations in color and sound are unlikely to place a high priority on such uses of the computer.

It is the purpose of this training module to introduce science teachers at the secondary level to effective applications of microcomputers for instruction. A secondary purpose is to provide as much information as could be compiled by the author on the current state of science related microcomputer courseware. Since there are a variety of machines in use throughout the state, it became necessary to select one to use as the vehicle

for presenting demonstrations of exemplary science courseware. The Apple II series was selected both because surveys show that it is the most common in Texas schools and because more educational software now exists for this microcomputer than for any other. There is of course no intent to promote one machine over another. Each of the other available machines has its own unique advantages and disadvantages. Appendix B lists periodicals and sources of science courseware available for users of specific microcomputers.

As with any new and rapidly changing technology, the best source of current information is other users. Some very exciting things are being done by science teachers using available resources. One way to find out more about computers in the classroom is to attend conferences where teachers describe formally in presentations and informally around coffee breaks how they have found new and effective applications for computers in science teaching. Among the best conferences available to Texas teachers are:

- Texas Computer Education Association (TCEA)
- Texas Association of Educational Data Systems (Texas AEDS)
- Conference for the Advancement of Science Teaching (CAST)
- Conference on Technology in Education
- Texas Academy of Science (TAS)
- National Science Teachers Association regional and national conferences (NSTA)
- and of course workshops like the ones for which this module is written.

The presentation of this module will be effective only where the presenter allows generous time for the exchange of ideas among practicing science teachers who

have legitimate concerns about the potential impacts of the microcomputer in their classrooms. It would be a serious mistake for the presenter to deliver the concepts of this module as a "briefcase expert". Teachers are often confronted with calls for change by those who do not spend the bulk of their own time in the classroom. It is pointless to imply that science teachers who do not actively use microcomputers are "computer illiterate". Many effective teachers have better methods of managing instruction then any contained in this module, and should continue to use such methods as long as they remain effective. The presenter's job is to describe and demonstrate current science software materials in those categories contained in the Learner Outcomes section. The job of teacher participants is to remain open to new techniques for teaching science made possible via microcomputers. Both presenters and participants must remain skeptical of the microcomputer's potential and critical of new approaches until they have been proven more effective than old methods. One of the most valuable outcomes of this two-day workshop may be the exchange of ideas and techniques engendered by the demonstrations and activities of the module.

Ultimately, curriculum is not driven by technology. Curriculum is not even defined by the textbook. Instead, it is as one experienced teacher put it, "what happens when the bell rings." If science curriculum is to be effective in producing citizens who can move into the jobs and culture of the new information age, it must be the product of creative teachers using the most effective tools available. These teachers must have the training, the equipment, and access to current information which will help them make science instruction come alive. The author of this module sincerely believes that the microcomputer offers opportunities for innovative instruction which every teacher should consider.

To the Presenter

This module is designed to provide for twelve presentation hours (two days) for demonstration, discussion, and active involvement for science teachers at the secondary level with limited background and experience using computers. It is divided into seven sessions to be presented in sequence beginning with Session #1, which provides an overview of the entire module.

It is assumed that the presenter has had classroom teaching experience in science at the secondary level, and moderate to extensive background using computers with packaged software. The presenter need not have any programming experience, but should feel comfortable using all of the selected science courseware materials included with this module. You will note that no script is provided for the presenter. The outline and materials list should provide enough information for you to deliver this material to teachers in a manner that fits your personal "style" and experiences. No one likes to spend two days listening to a canned script. Feel free to include anecdotes from your background with computers and science teaching. Just be sure to spend an appropriate amount of time with each session.

It is quite important that the presenter be open to discussion, and provide time for participants to critique each session's techniques and courseware selections. This material will use presentations and techniques new to many participants. They must feel free to examine and criticize the merits and disadvantages of content and delivery of each software package. Time is provided for this in the session outlines. However, you should avoid spending much more time on one session than is budgeted, even if some teachers request it. As long as one-fourth of your participants are unaware of the application in any session, you should provide adequate time for that session.

Prior to each workshop the presenter should check off the following items to assure that equipment and setting will be ready for the best presentation:

-- visit the room where the workshop will be held to determine number of Apple computers available, number of printers, seating, overhead projector availability, condition of equipment;

-- determine the number of participants, and run off sufficient copies of handouts for both days for the number plus extras for late registrants and host school;

-- make sure that sources of hot water and containers are available nearby;

-- make sure that someone will provide for completion of the certificates for all participants at the end of the second day;

-- provide for enough copies of diskettes so that each work station can have one diskette available; it is not necessary to have multiple copies of <u>each</u> diskette, since not all teachers will use each one.

Although it would seem that others should take care of the above preliminary checks, it has been found that failing to check on them can make the presenter seem incompetent. It is difficult to "simulate" a computer tutorial on a dead computer, or to describe in words what printout results would look like if only the printer were working.

Pacing is important if all material in this module is to be presented and absorbed by participants. The following pace has been found to be about right for an audience of average background and interest. Provide hands-on time at the end of each day so participants can use the software previously demonstrated.

For the purposes of this module, a "computer system" consists of:

__ one Apple II, II+ or IIe microcomputer with at least 48K of memory;

__ one video monitor (preferably color) of the largest screen diameter available;

__ at least one disk drive attached;

__ an optional printer (preferably dot-matrix).

For the hands-on time at the end of each day, a minimum of one system for every two participants should be provided.

DAY 1

Session #1	"Realities and Aspirations"	1.5 hours
Session #2	"Computer-Assisted Instruction	1.5 hours
Session #3	"Simulation, Tutorials, Graphics"	1.0 hours
Session #4	"Calculations, Analysis of Data"	1.0 hours
	"Hands-on"	1.0 hour

DAY 2

Session #5	"Collection of Experimental Data"	3.0 hours
Session #6	"Problem Solving Strategies"	2.0 hours
Session #7	"Conclusion, Evaluation, and Hands-on"	1.0 hour

1

Realities and Aspirations

Overview

This session covers:

Introductions, presenter and participant using the handout "To the participant."
Where you start: "The Realities" using Transparency #1: Taxonomy
Where you want to go: "The Aspirations" using handout "Goals for Use of Microcomputers in Sciences."
Can you get there from here? Software Evaluation using "Pages 4, 5, 6, and 7 from NSTA."
Has it been done before? Statements by teachers using handouts "Science Software in High Button Shoes," "The Computer in Science Education," and "How to Use the Computer in Science Class."

Learner Outcomes

The participant will:

- demonstrate awareness of appropriate uses for microcomputers in science teaching to facilitate learner inquiry, individualize science instruction, simulate experiments otherwise difficult or impossible to perform, collect and analyze laboratory data, and use the computer as a problem solving tool;

- recognize the dynamic nature of computer hardware and software, with resulting need for flexibility in adapting to new machines and new instructional uses developed either locally or commercially;

- be able to state the value and likely problems which result from local creation and revision of science software, and how this requires programming skills usually beyond the background or time available to classroom teachers;

- recognize that the computer can either be studied as an object of technology (computer science) or used as an inquiry tool of science; (this module addresses only the latter application of computers)

- be able to state six levels of use for microcomputers in science instruction, recognizing the increasing costs in both dollars and teacher skills involved in moving to higher levels;

- demonstrate knowledge of the sources of software and computer peripheral devices appropriate for use in science instruction;

- demonstrate skills in critical evaluation of science software using existing evaluation forms and criteria such as the one developed by the National Science Teachers Association;

- demonstrate skills in the integration of science programs and materials into existing curricula;

- demonstrate knowledge of appropriate instructional arrangements of computers, printers and display monitors for best access, security and management in science classrooms ad labs;

Equipment/Materials

Overhead projector

Transparency #1:	Taxonomy for computer-based education
Transparency #2:	Generic computer hardware configuration
Handout:	"To the Participant:
Handout:	"Goals for the Use of Microcomputers in Science"
Handout:	"How to Use the Computer in Science Class (And How Not To)"
Handout:	"Science Software in High Button Shoes"
Handout:	"The Computer in Science Education Defining the Role of Technology"
Handout:	NSTA Science Software Evaluation Instrument

Time

1½ hours

Presenter's Notes

1. Begin by introducing yourself to the participants and asking each one to briefly describe their school, their access to computers, subjects they teach, and why they are attending this workshop. If you have provided for nametags, and feel they would help participants (and yourself) establish more open attitudes toward discussion, distribute them.

2. Use the handout entitled "To the Participant" as a guide for describing the purposes of the workshop. Each participant should have a copy to serve as a program guide for the full workshop. At this time you should explain how breaks and lunch will be handled. Make sure everyone knows where restrooms and refreshments will be found. When and for how long will breaks be held? Participants may want to note these times on their handout. Encourage all to return on time after breaks.

3. Use Transparency #1, the taxonomy matrix of skills, concerns and proficiency levels. Explain each axis and its basis in research. Then ask participants to try and locate themselves somewhere in the three-dimensional cube where they feel they are now. Ask them to imagine a target cell where they would like to be within the next 12 months. Point out how time, access to equipment, and workshops like this one can help them move from where they are to where they might want to be. Also note that some teachers may already be about where they want to be. This workshop will not address the issue of programming computers, and thus will not move over the heavy vertical line on the taxonomy. Teachers should realize that writing their own computer programs is extremely time-consuming; about 50-300 hours of programming for each hour to student instructional time. So the purchase of commercial courseware or acquisition of public domain software is the only realistic alternative for most science teachers.

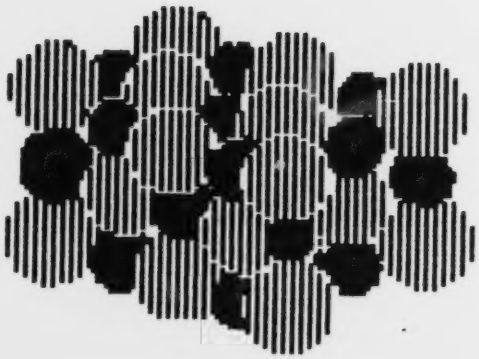
4. Display Transparency #2, the overhead of a typical hardware configuration for a microcomputer system. Discuss the variety of currently available microcomputers, and how software is machine-specific. Explain why the Apple II was chosen as the "delivery vehicle" for this workshop, and point out that other models may be as good or better for teaching science. Avoid arguments about the "best" machine. Describe Appendix A- "Representative Science Courseware" and offer to make it available to participants who wish to examine types of science software available for a variety of microcomputers.

5. Explain the need to keep up with current developments in new machines, peripheral devices and software of potential use in the science classroom. Describe Appendix B - "Useful Addresses and Sources of Assistances" and offer to make it available to participants who wish to know of organizations in Texas which offer assistance to teachers using computers. Note that sample periodicals for each common microcomputer are listed in this appendix, as are more addresses of science software vendors. Explain that each participant will be shown a collection of catalogs from representative vendors at the end of the workshop and provided with a form letter to write for catalogs.

6. Hand out the NSTA Science Software Evaluation Instrument. Examine it carefully with participants, explaining that it is the result of two years of refinements by a committee of the National Science Teachers Association. They may write on their copy, but note that they may prefer to use it as a copy master to make more forms for use in evaluating commercial courseware for their school. Encourage participants to discuss local needs in the science classroom and question whether microcomputers can help meet these needs.

7. Finally, hand out the papers written by other science teachers. Examine some of the points made in these papers. Note that not all of the statements are supportive of computers in the science classroom. Just because a computer can perform certain tasks may not make it better than alternative or traditional ways of performing these tasks. Someone has said that computers are very good at calculating but not at thinking, whereas humans are just the opposite. Each should do what they are best at doing. Ask participants to read

these short papers before returning tomorrow. They should make some notes of their personal reactions to statements in the papers. What points made by the authors do they find most surprising? With which statements do they agree? Disagree? Explain that tomorrow morning's session will begin with a brief discussion of the three papers.



CRYSTAL LATTICE

2

Computer-Assisted and Computer Managed Instruction

Overview

This session covers:

Drill and practice examples without graphics using Drefus Disk #1: "Significant Figure Drill"
Drill and practice examples with graphics using J & S Demo Disk "Biology"
Dynamic chalkboard examples user Vernier "Ray Tracer"

Learner Outcomes

The participants will:

- describe the relative strength and weaknesses of using the computer as a dynamic textbook, i.e. prompting the learner for recall of facts in a drill and practice mode;
- recognize and describe the value of interactive student control of options and pacing within programmed instruction;
- demonstrate skills in use of representative CAI and CMI science software as provided in this workshop;
- demonstrate skills in use of related materials such as student handouts, preliminary and follow-up activities, and student evaluation;

Equipment/Materials

One Computer System for demonstration
Dreyfus Institute Diskette #1
J & S Demo-X Diskette "Biology"
Vernier Demonstration Disk

Time

1½ hours

Presenter's Notes

1. Boot the Dreyfus Institute Disk #1. Select (6) to get the second screen menu. Select item (1) from this second menu. Read the screen description of this program, and point out that it is an example of a drill-and-practice program using only text - no graphics. This series was produced by chemistry teachers who were selected to participate in the Dreyfus Institute by the Woodrow Wilson Foundation. Since programs are written in BASIC, anyone who is fluent in this language can modify the programs for local needs.

2. Press [R] to run the program. Go through the 4-item menu in ascending order, asking for comments from participants. When you are quizzing the computer, try entering a letter instead of a number and note that this program is relatively "bullet-proof" against bad input. Not all software is this "hardy", especially not public domain software. Ask for suggestions on how to modify the drill (menu option #3) to better (a) motivate students, (b) test the concept of significant figures, (c) help the teacher.

3. After selecting (4) for "QUIT" from the menu, enter RUN HELLO [return] to get the main menu for this disk again. Select (6) for the second page, and then select menu option (5) BALLOON. After reading the description, type [R] to run and press [return]. Point out that this program uses primitive graphics to demonstrate the ideal gas law. Read each screen page, pressing [return] to go on. Any confined ideal gas has a volume that varies directly with temperature (measured on an absolute scale) and inversely with applied pressure. This is an abstract concept which can be made concrete by demonstrating the effect on the volume of a balloon of changes in temperature and/or pressure. Continue pressing [return] until you reach the graphics mode. Experiment with several changes in pressure and temperatue, noting the effect of each change on balloon volume.

4. Remove the Dreyfus disk and insert the J & S DEMO-X disk. Turn the computer off and then on again. Select item (3) from the menu - Biology Demo [return]. Enter some humorous first and last names as a ficticious student. Read and discuss the program description. Note the flexibility of presentation, wherein hints are given after wrong answers and more questions are given to students who answer incorrectly than are given to students who give correct answers. This is an important feature of good computer-assisted instruction. Point out that a file is created on the disk containing the names and scores of students who did the drill.

5. Press any key to continue, and read the screen description of photosynthesis and transport. Press any key to get the first question, which is loaded from disk. Type 99 [return] to see the plant cell structure. Ask participants for the correct answer, then deliberately misspell the last four letters of it and press [return]. Continue through all of the questions in this demonstration program, making sure to view the pictures for each. Ask participants what they think about the merits of graphics as used with this drill. Would it be as effective without graphics? This program tests recall of names for plant parts, not understanding the functions. Discuss this, and note that it is true of almost all drill-and-practice software. Is this good or bad?

6. When you have answered all four questions, your score is displayed and a record is written to the disk (which is why the disk has no write-protect tab on it). This file can then be retrieved by the teacher to record grades. This is a form of computer-managed instruction. Select item (7) from the main menu to view student scores in biology. Select the screen display option and look at the scores displayed. Yours should be one of them. Remind participants that this disk is only an abbreviated version of the full disks for each subject on the main menu. The disks are available from J & S Software, whose address is in Appendix B.

7. Boot the "Ray Tracer" disk from Vernier Software. Describe this as a dynamic chalkboard example of computer-managed instruction. If you have physical science teachers, ask them how long it takes them to draw diagrams of such things as rays of light approaching and being refracted or reflected

by changes in density of two media. Ask all participants to recall the tedium of drawing diagrams to describe dynamic concepts to students. How many teachers can draw good pictures of what either red or blue light will do when refracted by any material for 15 different incident angles? And all in less than two minutes? Examine the menu of options with "Ray Tracer". There are 15 different options, each with wide flexibility for teachers.

For example, in Mode A -Straight Interface (air - glass) the screen is divided in half, with the left side representing crown glass (refractive index = 1.5). Select A [return], and note the position of the source of light labeled "S" on the left of the screen. Point to the target square labeled "T" on the right. Explain that the object is to select an angle for a ray of light leaving the source so that it will strike the target and ring a bell.

8. Try an angle by entering any real number [return]. If you select one that misses the refracting surface, you will be told. The incident and refracted angles for each surface boundary are displayed at the bottom of the screen as the ray reaches the surface. Experiement with different angles until you hit the target and ring the bell. Ask participants for suggestions. Is there a unique angle which will always hit the target? Now clear the display by entering C [return] in response to the angle prompt. Move the source by entering R [return] and entering new horizonal (Z) (interface surface location) and vertical (-60 [Y] 90) coordinates for the source. Now ask participants for help to try again to hit the same target. Discuss participants' feelings about this type of science application of microcomputers.

9. Change mode by entering M [return] in response to the angle prompt. Select main menu option G [return]. Enter 200 for radius of curvature of the lens. The lens is drawn, and new positions of source and target are displayed. Try again to hit the target, encouraging participants to guess. This lens is made of crown glass, but lenses of other refractive indices are possible with this program. Of course there are formulae in physics which permit calculation of incident and refracted angles for a ray of light, but this program provides *conceptual* understanding of light reflection and refraction. It might be used before students do calculations or as a check on accuracy.

10. Change mode again with M [return] and enter LD [return] to get into demonstration mode for plane mirrors. In this mode you select the location of the light sources with reference to the target. Pick a horizonal (Z) value and a vertical (Y) value. Then try to hit the target again.

11. If you have several physics teachers or your audience looks interested, explore other menu options.

12. Explain that when rays of light leave a medium of higher optical density and enter a medium of lower density, it is possible for them to be totally reflected back into the first medium if the angle of incidence exceeds the critical angle. To show this (something that is *very* difficult to demonstrate in class), exit the program by pressing CONTROL-C [return]. Now enter EXEC TOTAL INTERNAL REFLECTION [return]. This runs a file with preset conditions and some pre-selected angles. You should try to find the critical angle, which is the one causing the light ray to run parallel to the interface. This angle can be easily calculated from the arc sin of the ratio of the external index of refraction to the internal index of refraction.

13. Discuss the fact that Vernier Software provides this disk without protection so users can modify the program to suit local needs. The 19-page manual includes a Teacher's Guide with suggestions for a variety of ways to adapt and use this program. List price is $24.95, including the manual.

Vernier
SOFTWARE

3

Simulations, Tutorials, Use of Graphics

Overview

This session covers:

Plant-animal simulation using the BSCS diskette, Volume II
Chemistry lab simulation using Dreyfus diskette #4
RAST: Molecular weight experiment using Dreyfus diskette #2
Geology Search using the McGraw-Hill diskette, the Newlandia map and records chart

Learner Outcomes

The participants will:

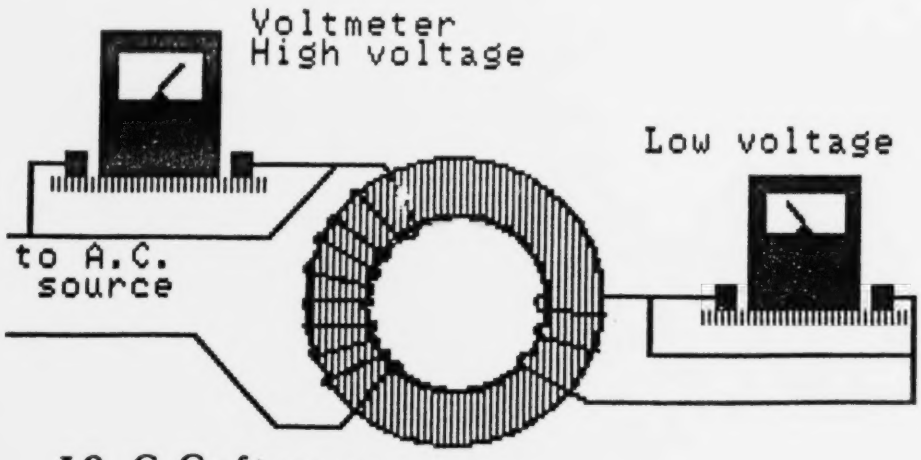
- demonstrate skills in use of the computer as an aid to classroom demonstration under control of the teacher;
- demonstrate awareness of situations when substituting computer simulations for actual laboratory experiments is appropriate;
- demonstrate knowledge of appropriate preliminary activities, prerequisite knowledge, and student grouping for computer simulations;
- demonstrate awareness of the value of graphics and color in computer simulations, with consequence implications for software evaluation and equipment selection;
- demonstrate skills in the use of tutorials and simulations in science as provided in this workshop.

Equipment/Materials

One computer system set up for demonstration purposes
BSCS Volume II
Drefyus Institute diskette #4
Dreyfus Institute diskette #2
Geology Search diskette (not included in this module)
Handout: Map of Newlandia
Handout: Company records

Time

1 hour



J& S Software

Presenter's Notes

1. Boot the BSCS Volume II disk and select menu item #2: "Plant and Animal Psysiology" from the main menu. Note the use of color graphics and sound as the program starts. Discuss its effectiveness with participants. The program begins by presenting a simulation tutorial of a controlled experiment designed to measure the effect of light on germination of corn seed. Questions are presented to the user on which variable is being controlled, what the experimental results indicate, and whether other conclusions are warranted by the outcome of the experiment. Discuss the importance of this situation for improving student process skills such as reasoning from observation, etc. Encourage participants to discuss screen prompts, user input and program response to each user answer. Point out that this simulation, like many others, works well with groups, with the leader/teacher managing input.

2. Another simulated experiment in this program examines the effect of a bell jar isolating one growing plant while a control plant remains exposed to air. Continue group discussion of simulation while you move through this program, responding to screen prompts with answers supplied by participants. Ask participants if they feel their program would be effective in helping students form reasonable hypotheses supported by their observations.

3. Continue with the next simulation of mice in open and sealed bell jars. You should demonstrate that perfectly good answers are rejected by the program as incorrect. Explain that the program is only examining a string of characters input from the keyboard in search of key words. The algorithm is simple and therefore pretty stupid. When you reach the question about INTERPRETATION or HYPOTHESIS, open the disk drive door after entering the correct answer but *before* you press [return]. Now press the [return] key and discuss

this type of system crash. What is its likely effect on (a) learners, (b) teachers, (c) faith in classroom computers? You can recover by turning the Apple off and back on again after you close the disk drive door. Do this, but don't go back into the program again. How "bullet-proof" should educational software be?

4. Boot the Dreyfus Disk #4 and select menu item (4) - "Chemistry Lab". Press [R] to run the program, then select menu item (1) - ACID TEST. Ask participants to look for something wrong with the content of this simulation. (Phenolphthalien changes to pink in the presence of *bases*, not acids.) This content error is not serious, but should serve as a warning to participants that computer programs, like teachers and textbooks, are subject to errors. Discuss this.

5. Examine the other three main menu options on this disk. You may re-boot the disk to get back to the main menu. Should there be an easier way? Remember that this is public domain software, and is actually better than average. At the main menu level, select option (1). Read the next two screen pages and return to the main menu by pressing return . Repeat for menu items (2) and (3). Explain that all of these programs will be available to participants for examination during the breaks and at the end of Day 2.

6. If you have a calculator handy and are comfortable with chemistry lab calculations, boot the Dreyfus Disk #2 and select menu choice #3 - RAST. This is a very nice high-resolution graphics simulation of weighing and heating an unknown pure substance to determine its molecular weight by RAST's method of using melting point depression. This simulation can be omitted to save time for the final activity, but should be used if you have several chemistry teachers as workshop participants. Discuss the proper use of lab simulations such as this one. Should they replace or supplement the actual experiment? How about their use *before* lab to help students understand the actions and calculations they must perform? Reading a balance to the nearest tenth of a milligram is a skill that can be learned from a computer screen almost as well as in the laboratory. Is this also true of filling and heating a melt-point capillary tube? What if a school does not have this equipment? This disk is free, but the equipment to do this determination might well cost over $1,000.00.

7. Sometimes a simulation works well with an entire class. A good example is the Geology Search simulation. This is available from McGraw-Hill for about $160.00, but all ESCs have a copy. Boot the diskette while you divide the participants into groups of three. Hand out one map of Newlandia and one company records chart to each group. Then run the disk demonstration by pressing [D]. Note the expected learner outcomes display on the screen. You should explain options available as simulated student input is displayed in the demonstration. After the demonstration, select [T] for teacher options, then menu choice (1) to begin new simulation. Discuss the use of graphics and updated team records displayed on the screen. Point out that this simulation takes about one week to complete in the classroom and can be resumed from previous states, since records of each team's status are preserved on disk. What are advantages of learning about geology in this way? What about realism and economic incentives? Pass around the Student Searchbook and Teacher's Manual. When the alloted time for this session is up, terminate play and discuss briefly simulation and graphics as used in this session.

Equilibrium Tic-Tac-Toe

by David Olney

4

Calculations, Analysis and Workup of Data

Overview

This session the presenter:

Discusses the computer as a calculator covering its advantages and disadvantages
Looks at data analysis programs using Vernier Software's Graphical Analysis
Offers practice in the analysis and graphing of sample lab data

Learner Outcomes

The participants will:

- describe those features of microcomputers and local school situations which make it practical to use the computer as a calculating tool;
- demonstrate skills in use of data analysis and calculating packages as provided in this workshop;
- demonstrate skills in selecting and locating an appropriate utility program for graphing or tabulating data, with knowledge of how to get output from an available printer;
- recognize appropriate and inappropriate student use of the computer as a substitute for hand calculations.

Equipment/Materials

Overhead projector
Apple computer system for demonstration purposes
Transparency #3: Postal Rates since 1958 data table and analysis
Transparency #4: Graph of Time (years) versus Cost/ounce (cents) for postal rates

Time

1 hour

Presenter's Notes

1. Begin by discussing some of the advantages and disadvantages of having the computer analyze and graph data for students. Include in the discussion

   a. Should students be forced to draw their own graphs, scale the abscissa and ordinate axes, label axes with appropriate units, title the graph and plot data points? The computer can do all of this faster than most humans. Is this an essential science process skill?

   b. How much is it worth to get a graph as fast as data is collected by student lab groups? Are some concepts easier to grasp if they are displayed graphically as soon as they have been measured?

   c) If regression analysis can "filter out" random errors, can this method be used to focus concepts that get muddled when errors obscure them? Isn't regression too tedious for most students to perform themselves? Should the computer do it?

   d) Who should determine the number of significant figures displayed in the final data? The student or the computer or the teccher? (Hint: It may be none of these, but the situation of the lab experiment and type of measurement made.)

2. Boot the Vernier "Graphical Analysis" diskette and note the main menu. This program is designed as a quick way to visualize data and draw graphs on any 80-column printer or the monitor screen. The user can manipulate the data in a variety of ways to try to achieve a straight-line fit so that a linear equation can be used to represent the data. Interpolation and extrapolation are possible, as is the display of data tables and saving of data to disk for later reference. Several sample data

sets are provided with the disk, and we will use these in lieu of actual experiments.

3. Select [L] for loading data from disk. Press [C] to see a catalog of the disk files [return]. Press [return] and then enter SAMPLE-FREE FALL [return] to load this sample set of data from a high school experiment. Upon return to the main menu, press [T] to print data table we just loaded. Press [return] since we don't want a printer output just yet. The screen now displays the student lab data in ten pairs with time measured in seconds and object free-fall speed in meters per second. Press [return] and then select [P] from the main menu [return]. Select [A] for automatic scaling [return] and then select [D] to plot points as dots. After discussing the resulting graph, press [R] to return to the plot menu. Continue experimenting with options in this way, including [L], [RP], [S], [DG], LN], etc. until you have seen what options are available to the user. The [S] option gives the slope and Y-intercept for the data, as well as a correlation coefficient. This is a powerful program!

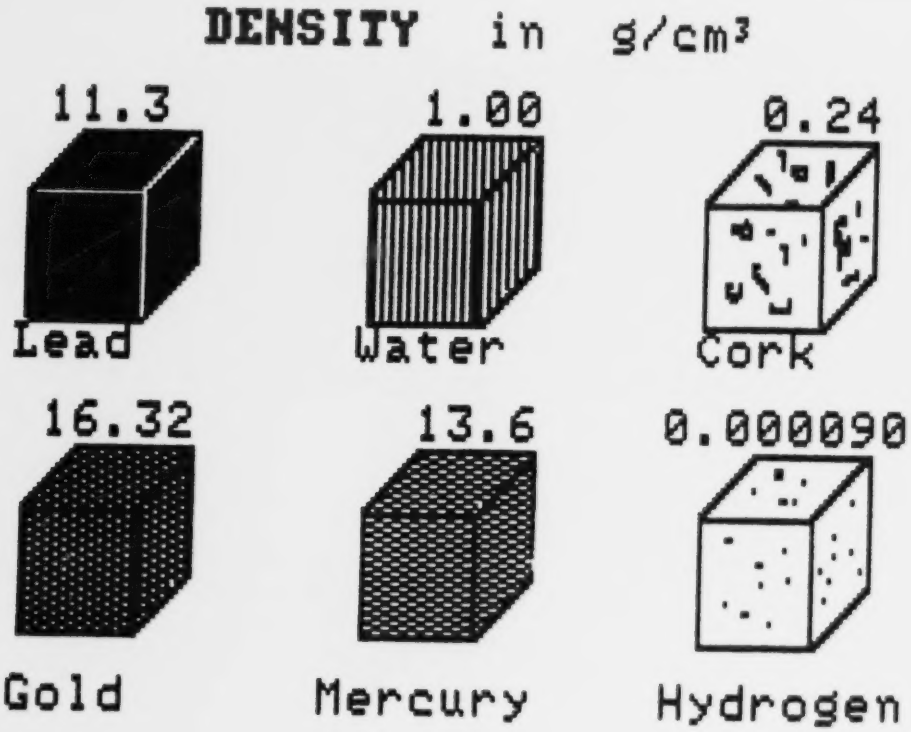
4. Select option [N] to perform numerical analysis on the above set of data for a free-fall experiment. This gives you current labels for both axes, number of data pairs, slope, Y-intercept, and correlation coefficient. You may interpolate or extrapolate from this option. Try it, asking for suggestions from participants.

5. Repeat steps (s) - (4) for the SAMPLE-POSTAL RATES SINCE 1958 sample data set. This time we need to manipulate the data to achieve a straight line. To do this, enter [PSL] [return] from the main menu. This asks that the log (base e) be taken in the Y-axis data before plotting the points. This semi-log graph of POSTAL RATES SINCE 1958 shows that the rates have risen exponentially - no surprise to most of us, but it produces a straight line on our graph. Thus, if we take the log of the postal rate in cost/oz and plot against time measured in years, we now get a straight line. Check the results by selecting [N] from the main menu. Use the two transparencies #3 and #4 as discussion guides.

6. To use a printer with this program, you must remove the write-protect tab from the disk. Be patient, the plot takes time to start up and run. This will even work on a letter quality printer.

7. If you have time, collect "live" data from the group on something like birthdays. Then enter this as month vs. number of birthdays. Get birthdays of all family members to collect enough. Is the result distributed randomly? Normally? Is there any relationship between the independent and dependent variable? Any other local data could be used better, especially if it shows a relationship which is linear or quadratic.

8. Use the remaining time to provide hands-on practice for participants using the software demonstrated in each of the sessions of Day 1. Take different disks to computer systems and place them near the disk drives. Have participants work in pairs or triplets grouped by subject matter area. This time is very important to allow participants to "experience" the demonstrated software.



J& S Software

5

Collection of Experimental Data

Overview

In this session the presenter will:

Discuss the handouts "How to Use the Computer in Science Class (and How Not To)," "The Computer in Science Education: Defining the Role of Technology, "Science Software in High Button Shoes."
Discuss the collection of laboratory data from experiments using the HRM demonstration diskette.
Perform six experiments in areas of chemistry, physics, physiology and earth science using the HRM Experiments Kit temperature problems, light and light sensor.

Learner Outcomes

The participant will:

- recognize types of peripheral devices remote sensing of laboratory data;
- be able to explain the purpose of a lab interface box;
- demonstrate skills in the use of data collection hardware and software as provided in this workshop.

Equipment/Materials

Overhead projector
Apple computer system for demonstration purposes
HRM Experiments in Science Demonstration Diskette
HRM Experiments Kit (not included in this training module)
warm and cold water
ice
styrofoam cups

incandescent light
Transparency #5, HRM Experimens in Science: Hookup
Handouts from session.

Time

3 hours

Presenter's Notes

1. Begin with a discussion of the articles by science teachers using microcomputers. These were distributed in Session I. The following questions are suggested to guide this discussion:

   a. What are some problems which may result from using computers in science instruction?
   b. Why is the science laboratory "an endangered species"? What can computers offer to help?
   c. What are some things microcomputers can do that cannot be done as well in other ways in the science classroom?
   d. What is the proper role of mistakes and "sweat equity" in learning science? How much should science students be spared this effort?
   e. What should be done about the absence of experimental error in simulated science experiments? Does this misrepresent data collection?
   f. Given a growing shortage of qualified science teachers, can microcomputers help out?
   g. What is the "bandwagon effect" of microcomputers in education? What are some of the risks to science instruction?
   h. Should students be forced to draw, scale, label and plot their own graphs?
   i. What does Mike Haney mean by the "danger that computers may move students away from discovery and inquiry and toward more content and structure"? Do you agree? Why?

2. Save the discussion of mircocomputers in science experiments to serve as a transition into the next part of this session. We will begin with a demonstration of how microcomputers can be used to collect data in "real time" from actual lab experiments. Point out that research scientists have been doing this for many years. Now that microcomputers are inexpensive and widely available, more science teachers at both the college and pre-college level are using them as laboratory

tools. This application is quite different from using the computer as a calculator or simulator of science information.

3.a. Boot the HRM Demonstration Disk and while it is settling down explain that it simulates experiments which can be performed using a kit of peripheral hardware for the Apple. This kit supports data collection and graphical display of over twelve experiments in chemistry, physics, physiology and earth science. Read the text screens aloud as they are displayed. Select from the main menu the following options in order:

1, 2, 4, 7, 8, and 11

1. *Cooling Curve* [return]; select [y] in answer to prompt of CALIBRATE THERMOMETER? Read the text screen, which describes what would be done if that probe were connected. Press [return] to go to the next screen. After noting the location of the temperature probe slot, press [return] again. Select 30 (seconds) for duration of experiment, and press [return]. Select 80 and 20 (degrees C) for maximum and minimum expected temperature. After [return] the simulated experiment is run and a cooling curve results from plotting the input temperatures over time. As a pure substance undergoes a phase change, its temperature remains constant. Note the automatic scaling of both horizonal and vertical axes. Discuss this. Press [M] to return to the main menu.

2. *Heat of Neutralization* [return]; select [n] for CALIBARATE THERMOMETER? since we already did that. At least pretend that we did. Press [return] again after noting the location of the temperature probe. Enter 1.0 percent for concentration of the acid. Note that almost no change in temperature occurs when this acid concentration is neutralized. Next press [return] and [C] to continue the experiment. Continue choosing acid concentrations of 5.0, 10.0, 20.0, 30.0, 40.0, 50.0%. Note the accumulating points on the second graph which are results of each neutralization. Select [T] to display a data table and [return]. Discuss the return to main menu with [M].

[6.] *Light Intensity* [return]; note socket location of light sensor and press [return] again. Enter 5.0 (meters) as distance from light source to sensor and press [return]. Note that now the screen display is for simulated movement of the light source toward and away from the sensor. Use CONTROL-S to stop and restart the random display of relative distance and intensity of light. Discuss, noting that the Apple is using the inverse square law of light intensity to display relative distances. Press [ESC] and [M] [return] to again return to the main menu. What is the feasibility of this method to measure distance? What things can interfere with collection of accurate data?

[7.] *Heart Rate* [return]; note socket locations of light sensor and light source and describe this setup. Here we use the light source and light sensor, joined and held against fingertip to measure heart rate by detecting variations in the amount of light transmitted through fleshy tissue as blood surges through blood vessels near the skin surface. The program measures and records the relative amounts of light reaching the sensor over a sampling interval, then averages and displays the heart rate in beats per minute for the interval. Discuss, then press [ESC] and [M] [return] to get back to the main menu.

[8.] *Response Time* [return]; note socket number and [return]. Read the description of time graphed in milliseconds [return]. Select 10 (trials) [return]. Read the screen and [return]. View the graph ready for input and [return]. Watch as data accumulate for 10 simulated student stimulus-response times. Discuss and press [M] to get back to main menu.

[11.] *Evaporation & Humidity* [return]; (n) since we already calibrated the thermometer. Note sockets for two temperature probes [return]. Note scaled graph and press [S] to begin collecting simulated data. The cooling effect of evaporation

on the temperature probe inside a wet cloth is observed. At constant temperature, if there is moving air over a damp surface, that surface temperature will vary directly with humidity, up to but not exceeding ambient air temperature. Discuss this and how it can be used to measure the relative humidity of air. The [Q] and [M] [return] to main menu.

3-b. IF YOU HAVE THE HRM EXPERIMENTS IN SCIENCE at this point you should turn off the Apple, connect the 16-pin cable to the game paddle port as described in the HRM Teaching Guide and shown in transparency #5 and connect the MICROscope box to the 16-pin cable coming from the Apple. Now connet the red temperature probe to a cable and plug it into MICROscope box. You can then proceed through the same sequence of six experiments which were just simulated on the demonstration disk, but this time you will be collecting "live" data. Turn to the appropriate section of the HRM Teaching Guide for detailed instructions on each experiment.

Participants will collect the data in teams which you help organize by subject matter taught. There should be at least a physcial science, life science and earth science team so that each category of experiment will have a team. Your job is to guide the process and discussion of the results, helping to insure that all participants take an active part. For simplicity you should use ice cubes in water to simulate cooling curve temperature drop and small amounts of warm water added slowly with stirring to cool water to simulate the heat of neutralization of an acid with a base solution. Point out that this is done only to move more quickly through the six experiments. The temperature probe also works fine when an acid and a base are mixed to study reaction enthalpy. Do selected experiments using this kit to collect "live" data in the remaining time.

Discuss such possibilities as spilling acid on the Apple - a potential disaster! Note the ease of equipment setup and speed of data

collection and display. Discuss some relative advantages and disadvantages of collecting data this way.

3.c IF YOU DO NOT HAVE THE HRM EXPERIMENTS IN SCIENCE KIT, you should continue with other simulated experiments from the main menu of the demonstration disk. Their numbers and description are as follows:

[3.] *Chemical Reaction Rates*: The rate at which reactions take place can be monitored by logging the changes in light tranmission as the reactions progress. Students may study a range of suitable reactions, determining the effects of temperature and concentration on the speed of the reaction. The iodine clock reaction from CHEM-Study chemistry is a classic example. A dynamic modeling program allows data to be matched to models of the rate-limiting reaction.

[5.] *Kinematics*: As in [4], we use intensity to measure distance. Distance, speed and acceleration can be derived from light intensity and graphed as a function of time. This measurement capability is used in situations with various types of motion, including constant acceleration and oscillation of a pendulum.

[6.] *Light-Energy Equivalence*: The energy in light is determiend by measuring the heating of a dark liquid caused by a bright light of measured intensity. The effects of different light sources are investigated. The result of these measurements are used in the *Insolation* [10]. experiment.

[9.] *Flicker Fusion*: This experiment measures individual response to a flickering light. The light on the MICROscope box filckers initially at a very slow rate and gradually increases this rate while the user

stands ready to press the spacebar when she can no longer detect any flicker, i.e. when the light appears to be constantly on. Then the experiment is repeated, but with an initial high flicker rate which slows down while the user stands by to presss the spacebar when she can detect flicker in the light. Individual variation is measured along with such variables as intensity contrast. Comparison of this detected flicker rate with the number of frames per second shown in movies and the oscillation rate of flourescent lamps is fun.

[10.] *Insolation*: In this experiment, students measure the heating capacity of the sun. Light intensity is measured, and total incident power is calculated. Measurements can be made continuously and automatically or entered under operator control.

[12.] *Weather Station*: Using all the probes, students assemble a weather station that can measure and record windspeed, cloud cover, temperature and humidity. The equipment can be developed and tested in the lab for actual long-term measurements. Extension cables would be needed for collecting outside weather data.

4. Of course, the HRM kit will perform all of these experiments. It is available from

HRM Software
175 Tompkins AVe.
Pleasantville, NY 10570

They have a toll-free number: 800-431-2050. The kit sells for $249.00.

5. If you finish this session before the alloted time is up, take a short break and go on to Session VI.

6

Problem Solving Strategies and Inquiry

Overview

In this session the participant will view the video tape, "Semantic Calculator" from Sunburst Communications

Work with the solution of written problems in science using the "Semantic Calculator" software program by Judah Schwartz discuss the application of the computer as a tool for problem solving.

Learner Outcomes

The participant will:

- describe differences between inquiry software and all other types demonstrated thus far;
- demonstrate awareness that formal thinking and science process skills can be enhanced by student use of problem solving software;
- demonstrate skills in the use of problem solving/ inquiry software and documentation as used in this workshop.

Equipment/Materials

Video tape recorder/television
Apple computer system for hands-on (one system for two participants)
Video tape "SemCalc" (located in supplementary Materials Packet)
Semantic Calculator diskette (not included in this training module)
Transparency #6 pages III-9 from Sunburst manual
Transparency #7 pages III-11 from Sunburst manual
Transparency #8 pages III-13 from Sunburst manual
Transparency #9 pages III-17 from Sunburst manual
Handout: Problem Page

Time

2 hours

Presenter's Notes

1. Begin by showing the 30-minute video tape of Judah Schwartz, Professor of Physics at the Universtiy of Califonria - Irvine, describing the importance of semantic clues in solving written problems in science and math. Dr. Schwartz demonstrates this program's novel use of the computer as a tool for helping students learn how to set up and solve problems which do not contain written formulas for their solution. This process, often called unit anlaysis, is now used by many science textbooks such as CHEM-Study chemistry, which publishes a separate booklet describing the approach. Although the examples used in the video tape are quite simple, the process is effective with higher level problems. In fact, it was the tool used by Albert Einstein to derive his famous equation E = m(c) squared.

2. When the tape is over, discuss the difficulties students have with problems which require that they read a textual presentation of a situation and determine which quantities provided to use in a solution for the problem. If you are familiar with the process of "unit" or "dimensional analysis", describe how it associates quantities with that which is being quantified. A useful reference is *Dimensions, Units and Numbers in the Teaching of Physical Sciences* by Ralph Cullman and Renee Ford. Discuss the fact that every quantity which is measured or counted must be associated with some matter of behavior for which it is an attribute. Problems can be more easily solved if the units associated with these quantities are used as a guide to setting up relationship among the quantified matter or behavior. Problem solving consists of establishing these relationships and doing mathematical operations on the given quantities to derive the desired results. This may sound complicated, but the "Semantic Calculator" makes the job easier by guiding

the user to set up the unique relationship which yields an answer with the units we expect it to have.

3. Now boot the "Semantic Calculator" disk from Sunburst Communications (39 Washington Ave. - RM. CL, Pleasantville, NY 10570; toll-free number 800-431-1934). If you have a printer connected to the Apple, answer (YES) to the first screen question. This will enable you to get a "hard copy" later. Now answer [YES] to the NEED HELP? question [return]. Select [1] from the HELP menu [return]. Move through the seven help screens by pressing the key to move forward or the key to move back. Discuss the advantages of having this HELP feature "on-line" for users. Make sure all participants understand how the calculator works and how it is quite different from pocket calculators, most of which do not interact users. Use the CTRL-R option to go to the pad and enter the quantities suggested and then return to the help screen by pressing [?]. Continue through the help screens, pausing for questions and discussion. Make sure all participants know how to erase the pad with CTRL-E [ESCAPE], how to perform operations on quantities shown on the pad, how to get help, and how to read or write to the NOTE screen.

.4 Use transparencies #6, #7, #8, and #9 as guides to solving the problems presented using "SemCalc", and the handout have all participants help you. Keep the transparency covered except for the line you are working on for each problem step. "PS" on these transparencies indicates the problem solver, while "SemCalc" refers to the computer screen.

5. Use the set of four problems below with SemCalc and the handout, Problem Page, to show that more complex problems can also be solved using this tool.

Convert 100 miles to meters.

$$\frac{100 \text{ mile}}{} \quad \frac{5280 \text{ ft}}{1 \text{ mile}} \quad \frac{12 \text{ inch}}{2 \text{ ft}} \quad \frac{2.54 \text{ cm}}{1 \text{ inch}} \quad \frac{1 \text{ meter}}{100 \text{ cm}}$$

Answer: 1.6 E 5 meter (160,000 meters)

$$\frac{30 \text{ mile}}{1 \text{ hour}} \quad \frac{1 \text{ hour}}{60 \text{ minute}} \quad \frac{1 \text{ minute}}{60 \text{ second}} \quad \frac{5280 \text{ feet}}{1 \text{ mile}}$$

Answer: 44 feet per second

A ball is shot vertically upward with an initial velocity of 192 feet per second. Where is the ball after 9 seconds if acceleration if -32 feet per second per second?

$$\frac{192 \text{ feet}}{\text{sec}} \quad 9 \text{ sec} \quad + \quad \frac{-32 \text{ feet}}{2\text{sec}*\text{sec}} \quad (9\text{sec}) \text{ squared}$$

Answer: 1728 feet - 1296 feet = 432 feet

How many ergs of potential energy are equivalent to 30 joules of kinetic energy? (One Joule is a kg-m*m/sec*sec and one erg = a gm-cm*cm/sec*sec.)

$$\frac{30 \text{ joule}}{1 \text{ joule}} \quad \frac{1 \text{ kg-m*m/sec*sec}}{1 \text{ kg}} \quad \frac{1000 \text{ gm}}{(1 \text{ m})} \quad \frac{(100 \text{ cm}) \text{ squared}}{\text{squared}}$$

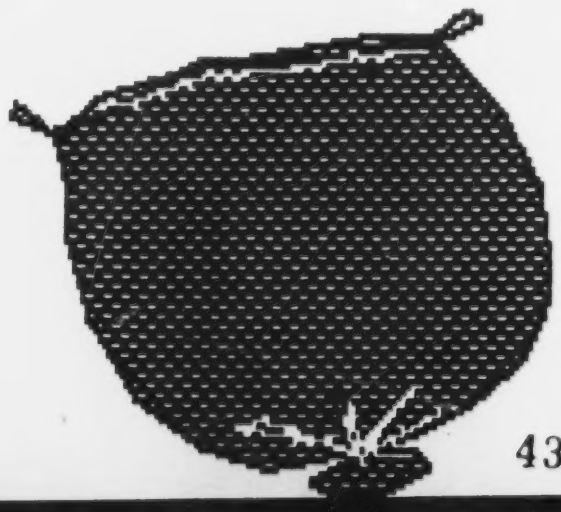
Answer: 30X E3 X E4 gm-cm*cm/sec*sec = 30 million ergs

---

5. Discuss the merits of using the computer in this way. How should the teacher be involved? Is this a good way to teach students to solve problems?

The number you saw was the volume of a bag of O_2 gas (measured in liters) at STP.

How many **moles** do you have in that bag?



7

Conclusion, Evaluation and Hands-on

Overview

In this session the presenter will:

Discuss the uses of microcomputers in science teaching and the roles of the teacher, student and computer within those uses.
Distribute evaluation forms for the workshop
Display vendor catalogs and distribute form letters.

Learner Outcomes

The participant will:

- Synthesize and close on the concepts and skills contained in all previous learner outcomes for each of the previous six sessions. This is quite important, and must not be left out. Six transparencies are provided to guide discussion of the uses of microcomputers in instruction.

Equipment/Materials

Apple computer system (one for each two participants)
Transparency #10 Drill and practice
Transparency #11 Materials generation
Transparency #12 Tutorials
Transparency #13 Educational Games
Transparency #14 Simulations
Transparency #15 Problem Solving
Handout: Sample form letter
Handout: Participant address and telephone list (created by presenter)
Certificate for participants (Appendix C)

Time

1 hour

Presenter's Notes

1. Point out that there are many other ways that computers can assist science teachers. Among these are:

   a. materials generation of tests and handouts for students using a word processor and printer;
   b. management of an inventory of supplies and equipment using a data-base program such as PFS -Personal Filing System- for the Apple;
   c. teaching of programming and computer science as a subject in itself using separate text-books such as those suggested for the new ETS Advanced Placement course in Computer Science.

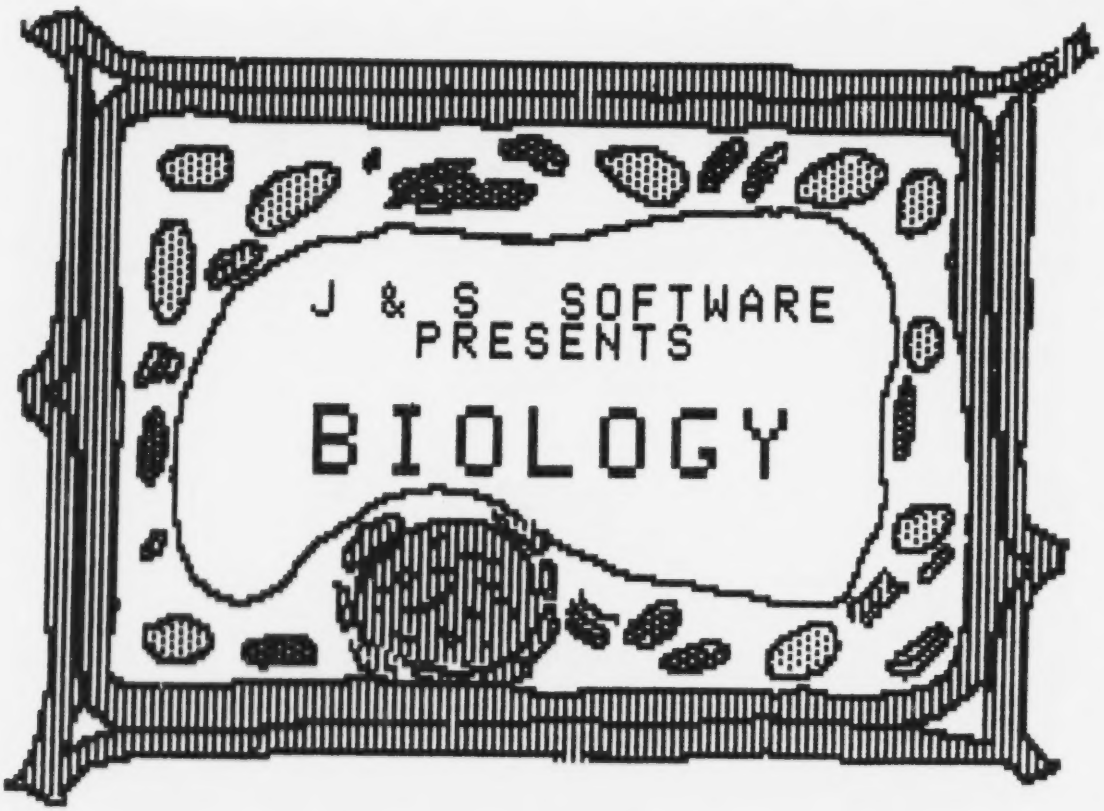
2. Use the included transparencies to summarize the first six sessions. Among closure questions should be:

   a. What have we learned about the potential of computers in science instruction?
   b. What are some disadvantages of using the microcomputer in science?
   c. What is your opinion now about using the computer with your students?
   d. Where should you go from here?
   e. What budget do you have and how much can you do with it?
   f. Keeping in touch with other teachers who attended this workshop can be very useful. If all participants are not from the same school system, pass around a paper for them the list their names, school addresses and phone numbers. If there is not time to duplicate this on the spot, ask if a participant will volunteer to duplicate the list and distribute to all listed addresses.

3. Hand out a certificate to each participant who attended all six sessions of the workshop. These should have names carefully typed and be signed by

you, the presenter. An example is provided in Appendix C.

4. From the packet of supplementary material, use the sample set of catalogs from vendors of science software as a example of what participants may obtain free for the asking. A sample form letter is provided as a handout. School letterhead should be used whenever possible when requesting free catalogs. Explain that these vendors are only a sample of all those now selling software for secondary science use. Simply writing to a vendor and asking to be placed on a mialinglist is often enough to get a collection of future versions of these catalogs.



To the Participant

This twelve-hour workshop is designed to present you with tools you can apply for more effective teaching of science through the use of the microcomputer. There will be seven sessions presented over a two-day period as shown below.

DAY 1

Session #1	"Realities and Aspirations"	1.5 hours
Session #2	"Computer-Assisted Instruction"	1.5 hours
Session #3	"Simulations, Tutorials, Graphics"	1.0 hours
Session #4	"Calculations, Analysis of Data"	1.0 hours

DAY 2

Session #5	"Collection of Experimental Data"	3.0 hours
Session #6	"Problem Solving Strategies"	2.0 hours
Session #7	"Conclusions and Evaluation"	1.0 hours

This module assumes that you are teaching physical, biological or earth science at the secondary level. It *does not assume* that you are already familiar with microcomputers, programming, or the use of peripheral devices which can be connected to microcomputers for collecting data. If you are already using computers in your science teaching, please let the presenter know during the get acquainted time in Session #1 so your knowledge and experience can be used to strengthen the workshop. The number of participants has been kept small to encourage interaction and exchange of ideas.

You will be given materials to take with you when you leave. These include three articles by science teachers successfully using microcomputers in a variety of ways, current addresses of software vendors who sell science courseware, and specific materials related to each of the categories of computer applications to science teaching. You will recieve a certificate for successfully completing the full twelve hours of the workshop.

Although the presenter will attempt to provide a complete demonstration of a variety of ways science teachers can utilize microcomputers to improve the quality of teaching and learning, and you should feel free to ask questions at any time during the workshop, you may find that your best resource for ideas is sitting next to you. Local teachers can and do find better ways to apply technology to teaching through practice and experimentation. New and better science software is becoming available on a variety of small and inexpensive computers every day. One good source of information on new courseware is one of the periodicals published for users of a specific model computer. The presenter has a list of the addresses of these publishers.

It is impossible to include in this module all of the best examples of new tools for science instruction. It was necessary to select one type of computer to use as the "vehicle" for the presentation of the content of each session. The Apple II series was selected because it is the most common classroom computer in Texas and because more courseware is currently written for it than for any other brand of hardware. Of course much of what will be demonstrated will work with other computer models. If your school has another type of computer, check with the presenter, who has listings of periodicals and vendor sources for other machines.

Please feel free to offer suggestions during the workshop if you know of ways that the computer has made your job easier (or harder). Some of the best information on good teaching can be harvested around the coffeepot during the break.

NOTES

Goals for the Use of Microcomputers in Science Instruction

I. Delivery of instruction

   a. drill and practice ***

   b. tutorial help for students ***

II. As a student tool

   a. calculation aid to reduce numerical data

   b. storage of information for later reference

   c. display of data in graphical or statistical form ***

   d. student programming

   e. collection of data in laboratory settings ***

   f. simulation of difficult or dangerous experiments ***

   g. means of learning better problem solving and critical thinking skills ***

III. As a teacher tool

   a. record keeping as in grades, inventory, test question bank

   b. testing of students in interactive mode

   c. dynamic "chalkboard" during demonstrations ***

*** examples of science software designed to meet these goals are included in this module

HOW TO USE THE COMPUTER IN SCIENCE CLASS (AND HOW NOT TO)

There are some useful applications, but beware of putting a screen between the child and the natural world.

By Michael Rossman

Since I'm the science teacher in an alternative school, it did seem my duty to lead our advance into the Cybernetic Revolution. It took a year to help push and cheer my colleagues and the administrator into getting a computer. And now that our first system's here, I can relax and confess: I'm not really interested in using it in my own teaching.

To be more precise, as I told my colleagues at the meeting where we finally decided to take the plunge, I'm not interested in using it very much. Nor was I the only one dubious about the well-hyped advent of computers in schools. Most of our staff don't expect to find much use for computers, especially with early grades children.

Our reasons for these stances and expectations are worth explaining in all their variety—but here I focus only on my own perspective as a teacher of science. Some of my reservations have to do with the fact that I teach grades 4 to 6; I do expect that additional positive uses for computers will emerge as students go on in school. But even teachers of higher grades may find that some of the same reservations apply, not only to science teaching but to most other subjects.

One marvel of our age is the way that even young and progressive people can sound and feel like crusty old reactionaries if they hesitate to jump into the arms of the latest technological advance. But I think of the ideas I explore here as conservative in a better sense, seeking a positive ground, asking what educational values we should hold and support in relating to this new tool. To ask this

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ILLUSTRATION BY JOHANA HOGENKAMP

question may lead us not only to resist many possible uses of the computer, but also to a sharper sense of purpose and a more intelligent commitment to the uses we care to make.

What To Teach About the Computer

Let's start with the question of teaching *about* the computer itself rather than teaching *with* the computer. Although it's an interesting topic from many other subject perspectives—social studies, economics, language, math—a science teacher would seem to have a natural mission to explain to students all about computers and computing.

But one reason I don't want to spend much class time on this topic is because it isn't really much of a science subject. The computer is a technology instead, a tool, sort of a general-purpose information appliance—and though I think schools should help kids learn about such basic tools as cars and sewing machines, that's not my main job as a science teacher. Computers are becoming prevalent so rapidly and there'll be so many chances to learn about them that it's not a high priority for me to be the one to do this job.

I do want to teach the kernel of science that lies within the fruit of technology—the gearing and leverage of the sewing machine, the car as transformer of stored biological energy. But since the deeper intricacies of doped semiconductor behavior are beyond even sixth graders, what's left to teach about the computer's physical mechanism itself is relatively very simple: The CPU directs electrical flows through an ingeniously connected array of on/off circuits, made very small by using lenses, photosensitive chemicals, etches and deposited vapors; the disk drive makes and senses little magnets storing on/off patterns; phosphors glow on the monitor screen.

Each item of basic science here should be familiar to children by the sixth grade—not from computers but from larger, simpler, and more common artifacts and experiences. Once kids grasp these ideas, they are taught easily enough for students to understand how the computer's hardware cleverly puts all these elements together.

Computing's more novel science lies in the nature of logical circuitry (and/or/not gates) and in the ways that information can be stored and manipulated as bivalent on/off patterns—but really, these concerns are more the meat of mathematics and logic than of science, which is less abstract. Some basic elements of computational logic can be taught during the early years of schooling, and I think they should be—not so much for logic's sake as to demystify the nature of computer "thought." Indeed, general teaching about "how computers work" makes more sense as an antidote to mystification—i.e., as a social project—than as a strictly scientific subject.

As for logic, it might seem—particularly in teaching science—that we should be concerned with the early development of logical perspectives and prowess, and that working with computer programs and programming can offer students powerful models to influence this development. But I'm not sure that all this should be encouraged so enthusiastically and simplistically. One thing about science as a cultural pursuit is the way its mundane practices and technological productions have become divorced from intuition, metaphor and dream, and from social rationality and control. It's not at all clear that *teaching science well* means to emphasize and accelerate this drift.

In this light, the vision of improving science education by having students use the computer as a kind of exercise machine to build logic muscle seems not only deficient but dangerous—unless this exercise is coupled explicitly with even stronger exercise to rebuild the missing connections and powers that might make our science healthier, whole. Meanwhile, to have students learn most of their science in terms of what can be conveyed through computers is to court this related risk: that they will identify the structures of logical thought that computer "thought" emulates with *scientific thought* itself. But programming can emulate only an impoverished model of the real thing.

> Every tool handled in continuous use leaves its distinctive imprint. The computer is a mind tool that will leave its imprint on thought itself.

Every tool handled in continuous use leaves its distinctive imprint on the flesh, as in the blacksmith's blackened knuckles and great biceps. The computer is a mind tool, humanity's first since the book, that will leave its imprint on the flesh of thought itself, shaping our development to fit its demands. The danger is that young users will (involuntarily, unconsciously) model their own thought processes to fit those encountered via the computer, and they are only the most readily mechanizable aspects of something more whole.

The Flat Reality of the Video Screen

Other reasons that I'm not very interested in teaching about computers or with their aid have to do with more positive priorities for what's worth teaching and how. As a science resource teacher, I want to spend more of my

limited time teaching students about the many and complex lives of this world, and about knowledge and experimentation as ways of loving the world. I think that is what they—and the rest of the world—need to be reconnected. Unless some recently reborn values prevail, our time and society will continue to divorce children and other citizens from contact with and love for the merely natural. Given this certainty, I think that to teach natural science should be to teach not logical analysis alone but reconnection, helping to heal what the notion of our dominion over nature breached long ago.

In grade school at least, computerization can play only a minor role in this reconnection. It's simply more important for children's development for me to take them to the vacant lot in the next block, or to search the unnoticed eaves and corners of the school itself to see the populations of small invertebrates, watch them changing as the seasons change, than it is to spend time showing them how to relate to or through a terminal.

To put it this way may seem a quaint heresy these days, when computer companies, pundits and a stampede of educators and parents are proclaiming that the most precious use of technical teaching time now is to train the youngsters in "computer literacy" so that they won't fall behind in the great rat-race of grades and jobs and future incomes. But isn't that the heresy, the real affront to whatever pure spirits of science there may be? For I still feel that the essential purpose of learning science, beyond the power it grants us in school and life, is to grasp who and where we are in the universe and how it works. To this purpose computers have little relevance, except as an incidental tool.

There is something irreplaceable about experiencing the material world, rather than simply absorbing ideas about it through the flat video screen.

It isn't that I just prefer teaching biology. I want to teach physics too as something sweaty and real—the mind of the material creature probing at the material world. Centrifugal force, hot steam, the spark and shock of electricity, the glare of spectral light—any of these phenomena can be cleverly modeled in a computer simulation. But no simulation can reproduce or substitute for the *experience* of the phenomenon as a stimulus to thought, or provide the deeper dimensions of understanding that come with recapitulating in private the historical, social progression from encounter to insight and mastery.

There is something irreplaceable about experiencing the rich gritty sensorium of the material world, rather than simply absorbing ideas about its simulacra through the perpetual flat reality of the video screen, which reduces everything one might experience to a phosphor ghost of itself. (Books do something analogous yet different, leaving the mind purely to imagine the reality, rather than tricking the senses to substitute for it.) This argument holds for subjects other than science, and for media other than computers—"educational" television, for example, which with its greatly varied curriculum also teaches the monotonous lesson that you learn by passively watching a prepared program on a screen.

Even with joysticks and interactional programs, then, the massive use of computers not just as occasional tools but as the very medium of learning in the classroom promises a general homogenization of learning, a tremendous reduction in the variety and vitality of educational experiences, of life in general, and of material experiment as the substrate of scientific learning. Given this situation, my duty as a teacher to regulate young people's use of computers in the classroom seems like my duty as a parent to regulate TV use at home—it's not only to favor educational programs over idle packaged games, but to set tight limits on *how much use* they make even of the best programs, in order to keep the young in richer touch with the broader variety of learning experiences.

Teaching Kids To Appreciate Tools

Similar reasoning leads me to be concerned about when and how students are introduced to "application" programs that perform complex and/or monotonous work for them. To give a child a program that coughs up the prime numbers in sequence before she has first gone past 100 finding them for herself is to keep her from the experience of actually chewing on the infinite gristle of natural numbers. One must experience the qualities of mathematical entities directly, I think, rather than read reports about or results from them, in order to even grasp the meaning of reports, let alone to imagine and construe new results.

Our new computer will offer my sixth grade students software that interfaces with sensors, automatically recording and analyzing environmental data. But before they use such a sophisticated tool, I want them to have sat for hours with paper and pencil, watch and thermometer, recording the speed of dawn's warming or something else that brings them more than once full cycle from gathering the raw data through making sense of it.

If there's a trace of Puritan spirit in all this, involving

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the idea that one should suffer a bit, or at least put in some hard work, to be worthy of the reward of the tool —well, I don't think that's inappropriate if it leads us to be consciously grateful rather than blasé about the powers granted us. But I think of this way of staging access to computer applications more positively, as a way to ensure that the tool is experienced as a sensitive extension rather than as a numb and numbing crutch. You can't really know what's gone into a process until you've done it yourself. After that you can use the quick tool in a different relation and appreciation; but without the knowledge of experience its use will always be mystified.

Computer Strengths

After so many cautions about what computers can't replace, some *do's* and *don'ts*—some authentic priorities and purposes for computers in the classroom—stand out clearly.

Since we want to use computers sparingly, the *kinds of uses* we choose should be absolutely first-rate. Computer aid should not reduce the breadth and variety of learning modes employed in the classroom, and should be used less to substitute for other modes than to provide important experiences that can't be gotten in other ways. Therefore, there's not much point in using computer drills to mechanize the rote learnings of math and science—the multiplication table, taxonomies of biology and geology, and so on—even though it can be readily and effectively done. It's better to downplay rote learning altogether, and use the freed time and energy to encourage creative learning uniquely furthered through the computer.

> We must ensure that the tool is experienced as a sensitive extension rather than as a numb and numbing crutch.

The turtle geometry associated with Logo is one such suitable element of computer curriculum. Another example is the game *Rocky's Boots*, which helps children to grasp logical operations by manipulating them in tangible form to enable real operations on the screen (when the boot comes to the item that is "red or blue and not-yellow and not-square," it kicks.

Another sort of example is given by simulation programs in physics and astronomy, programs that permit students to vary the mass, velocity and so on of bodies in orbit, and see how the orbits respond. Here the computer's legitimacy comes from the fact that the simulated experience is richer and more real than the "real" experience, which consists of analyzing numbers and pictures recording the motions of unresponsive objects too far away to touch.

Yet another example involves an evolution simulation program that sends random birds pecking after light and dark moths interbreeding on light and dark grounds, to demonstrate the pressures driving the adaptation of camouflage. The legitimacy is weaker here because we can demonstrate evolutionary adaptation more concretely and directly with bacteria even in grade school, adapting them to concentrations of some toxin. Video moths may be more vivid and active than bacterial colonies on an agar plate; but in sound pedagogy the bacteria would come first before running such a simulation.

These are some of the few "educational programs" that excite me, and that's another point. Most of the educational software available so far is unimaginative junk. Consequently, it's probably better to keep the software store small if not spartan, featuring quality—and not to get programs just because they're available or because you think you should, out of a sense of duty because "the students should have tools to help them drill for this and that." Dreary routines there will be; but why cooperate in teaching children that that's what learning is about? I want to bend my efforts and software instead to imbuing the pursuit of learning science with passions of curiosity and adventure.

In this light it's important to use yourself as guide. Don't get a program unless it's genuinely exciting to you as a teacher, at least on your students' behalf and preferably also on your own—and also unless it is demonstrably more useful than a good book. Such fully grown-up applications as word processing, spreadsheet and relational data base programs deserve special attention as basic utilities that should be made available as soon as children have enough relevant experience to understand why their powers are exciting.

In many schools, the practices of education have already been too much reduced to conducting students through routine drill and homework, and recording attendance and grades. Computers can be used so naturally to do all this more systematically and efficiently, that they surely will be, and the results will probably be taken as the very definition of better education. Given this context, teachers who want to use computers to change the nature of classroom education will need to be very conscious and selective about the uses they encourage. ■

Michael Rossman is a teacher and writer in Berkeley, Calif.

SCIENCE SOFTWARE IN HIGH-BUTTON SHOES

By Odvard Egil Dyrli

Is science software pushing teaching back to the days of high-button shoes? Here's help in finding experientially based programs that support newer teaching techniques.

Computer technology in the classroom is supposed to enable teachers to teach more effectively and help students to learn more quickly and easily. However, computer software technology has, for the most part, lagged far behind current learning theories and practices. Nowhere is this lack as evident as it is in the computer curriculum for science.

Prior to the space race, the science curriculum was rigidly textbook-based and characterized by an emphasis on student acquisition of arbitrary trivia—memorization of facts, terms and definitions—and quick recall of these stored bits of knowledge. Classroom activities were usually performed by the teacher and did little more than confirm what had already been concluded by the text. True experimentation, where the outcome could not be known in advance, was seldom part of science instruction, and students and manipulative materials were kept apart.

Throughout the sixties and into the seventies, however, the science curriculum underwent massive changes in organization and emphasis, and through these changes students and materi-

"Science Software in High-button Shoes" by Odvard Egil Dyrli
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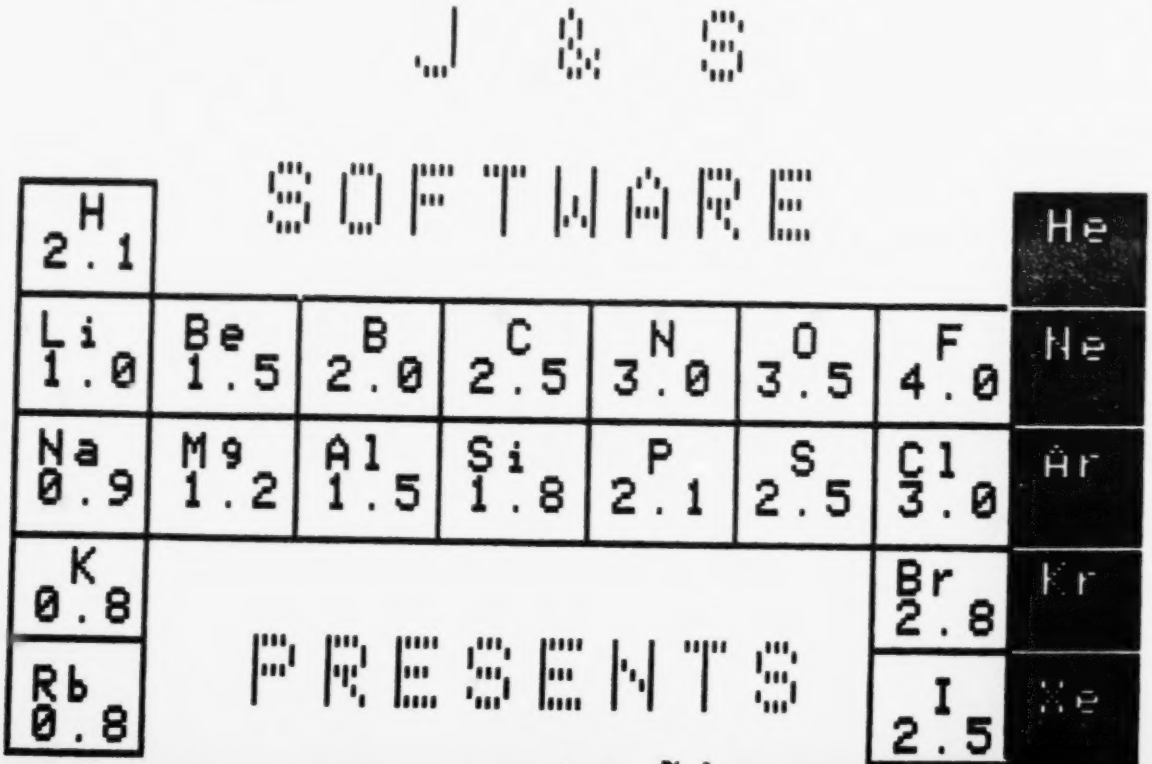


als were brought back together. Curriculum attention shifted from content acquisition by students to developing intellectual process skills—including observing, measuring, hypothesizing, predicting and experimenting—and to working directly with manipulative materials. The expository approach of textbooks was put aside, and "inquiry-oriented" teaching, where students came to their own conclusions based on evidence gained in the laboratory, became prominent. Thus the "process-centered era" in science-curriculum design was ushered in. This approach was believed by curriculum designers to be of far more lasting value in that it equipped students with intellectual skills that would persist long after the facts, terms and definitions were forgotten.

Leaping Backward With Computer Technology

The advent of the computer should mark the beginning of an exciting new era in education, an era that reflects the advances we've made in curriculum thought and development. But today the widespread use of microcomputers for science instruction is characterized instead by a curious phenomenon: much of the available science software is based on outdated content and memorization. Through computers, we've taken a giant leap backward in education!

The earliest science software and many of the products now offered for computer-based science instruction were developed as if the advances of the process-centered era had never occurred. Instructional presentations are again pedantic and expository, and the emphasis has returned to student acquisition of factual information. Examples include rote tutorial instructional sequences and a variety of multiple-choice, fill-in-the-blank, word-matching, scrambled-word and crossword formats, all dealing only with the verbal content of science. Students' thinking skills are seldom engaged, and instruction is limited to the confines of the computer instead of using the computer as a tool for interpreting and understanding the world beyond the keyboard. Ironically, the computer used in this way is bringing us back educationally to an era long gone in teaching—the era of science as memory work—and we are seeing "science software in high-button shoes."

One of the major reasons for the lack of progress in

EXAMPLES OF PROCESS-CENTERED SCIENCE SOFTWARE

Cat Lab
Level: Grades 9 and above
Hardware: Apple II series (48K); disk
Publisher: Conduit, The University of Iowa, Oakdale Campus, Iowa City, IA 52242

A comprehensive genetics simulation in which students "design" cats according to coat characteristics, and then breed and crossbreed the animals to determine inheritance patterns of various traits. Parent cats and offspring are displayed on the screen, and genetics features are described. Students experiment to determine characteristics that are dominant, recessive, sex-linked or related to one another by breeding cats in the population and analyzing the results. *Cat Lab* can be conducted at relatively simple and very complex levels of difficulty.

Geology Search
Level: Grades 5–9
Hardware: Apple II series (48K); TRS-80 III, 4 (32K); Franklin 1000 (48K); disk
Publisher: Webster Division, McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, NY 10020

Students compete in teams to interpret geologic features and predict where oil is within a mapped area. Teams perform a variety of tests to gain more information before deciding where to drill. *Geology Search* requires mapping and communication skills, and the interpretation of scientific data. The program also includes studying the economics of pricing oil for world markets.

Rocky's Boots
Level: Grades 4 and above
Hardware: Apple II series (48K); disk
Publisher: The Learning Company, Suite 170, 545 Middlefield Rd., Menlo Park, CA 94025

developing process-centered science software is that the first developers of educational software were primarily programmers without teaching backgrounds. They were not subject specialists in the curriculum content areas for which they worked. Furthermore, few science content specialists had yet become involved with computer-aided education. The result was the development of science software naive both in its concept and in its instructional design.

In the past, competent teachers who were required to use weak textbook series could choose from among the better sections of texts and emphasize manipulative inquiry activities. But computer programs are not adjustable in instructional emphasis and can seldom be used easily in part. The adoption of computer-based curriculum materials, therefore, has put the teacher in the position of being a part of a captive audience along with the students.

What Should Learning Science Be Like?

Inquiry-oriented science instruction at any level involves more than the selection of programs—it is a teaching approach that is crucial to learning. Although acquisition of content does, of course, have a major place in the curriculum, inquiry-oriented curricula should empower students to seek answers to questions through scientific inquiry. Such investigation may require interaction with physical materials and may involve inquiry applied to the body of content itself—involving information searches, surveys, interviews and other investigative devices.

Learning theory and research strongly support the contention that the only way for students to develop scientific skills and understand concepts is through direct, firsthand involvement with science as a process. The implications for curriculum development for inquiry-oriented learning are that student science materials should place central emphasis on developing the inquiring mind of the student and on encouraging a scientific approach to problems. That means providing opportunities for exploring and ordering observations in every scientific content area—from simple activities to more complex. It also means providing the student with the skills and knowledge necessary for formulating appropriate inquiry questions and offering direction in

Rocky's Boots is an outstanding example of science software that can be used effectively on a variety of levels. In an exceptionally creative format, it makes the sophisticated content of microelectronics and the design of logic circuits accessible, even to elementary school students. Students move about freely from problem room to problem room within Rocky the Racoon's house, and learn to construct electronic logic circuits from component parts.

Tell Star
Level: All grades
Hardware: Apple II series (48K); IBM PC (128K); disk
Publisher: Scharf Software Systems, Inc., Suite 1068, 2111-M 30th St., Boulder, CO 80301

An amazing program in which students can identify any place on earth by longitude and latitude, and specify the time, date and year—past, present or future. The computer determines and then displays a map of the heavens for the time and place selected. *Tell Star* allows a variety of experimental inquiry activities, such as the tracking of celestial bodies.

Volcanoes
Level: Grades 7 and above
Hardware: Apple II series (48K); disk
Publisher: Earthware Computer Services, P.O. Box 30039, Eugene, OR 97403

A well-formulated educational game in which students predict volcanic eruptions in a mapped region and learn about how volcanologists use scientific test data to study potentially active volcanoes. The importance of cooperation in limiting the damaging effects of dangerous natural processes and understanding natural phenomena are stressed. Includes colorful graphics.

What's In Your Lunch?
Level: All grades
Hardware: Apple II series (48K), disk; Atari 400, 800 (32K); Commodore PET (16K), cassette or disk
Publisher: Math and Computer Education Project, Lawrence Hall of Science, University of California, Berkeley, CA 94720

A concise and effective tool for demonstrating how an individual's specific food choices influence nutrition. Students enter personal data on height, age, sex and level of physical activity, and then specify food items in a hypothetical meal. The computer prints out a graphic picture of the meal's nutritional content, and students can experiment and note the effects on the computer printout of adding and deleting individual food items.

devising their own experiments and investigations.

In applying an inquiry-oriented curriculum, younger students, for example, may learn about electrical conductors and insulators by using flashlight cells and bulb circuits to compare the kinds of materials in the classroom that allow electric current to pass and those that do not; or they may experiment with concepts of density by comparing various objects that float in water. Older students may conduct investigations that compare the surface tensions of various liquids; or investigate the frequency and distribution of plant or animal species in a given area. In each case, the inquiry-oriented curriculum requires students to gather real and unpredictable data, interpret findings critically and learn about their own environment through personal experience.

Some newly developed science software truly engages the intellect of the learner and captures the spirit of intellectual inquiry.

Looking Ahead With Microcomputers

Recent developments in the level of sophistication of instructional software are cause for optimism. More and more software developers are recognizing the importance of uniting educators, subject matter specialists, learning theorists, instructional designers and programmers to create process-oriented programs. Some of this newly developed science software truly engages the intellect of the learner and captures the spirit of experimental inquiry. Students are required to exercise and develop process-centered learning skills and arrive at conclusions based on evidence. For some programs, data from the student's environment is brought to the computer for analysis; for others, learning is extended back into the concrete world of maps, books, artifacts and all sorts of other manipulative materials.

Even if you have only one microcomputer available in your classroom, some of these inquiry-oriented programs can be valuable teaching tools. When the computer functions as a tool for inquiry, it enters student investigations at various times and in various ways, and so a single computer can be used meaningfully.

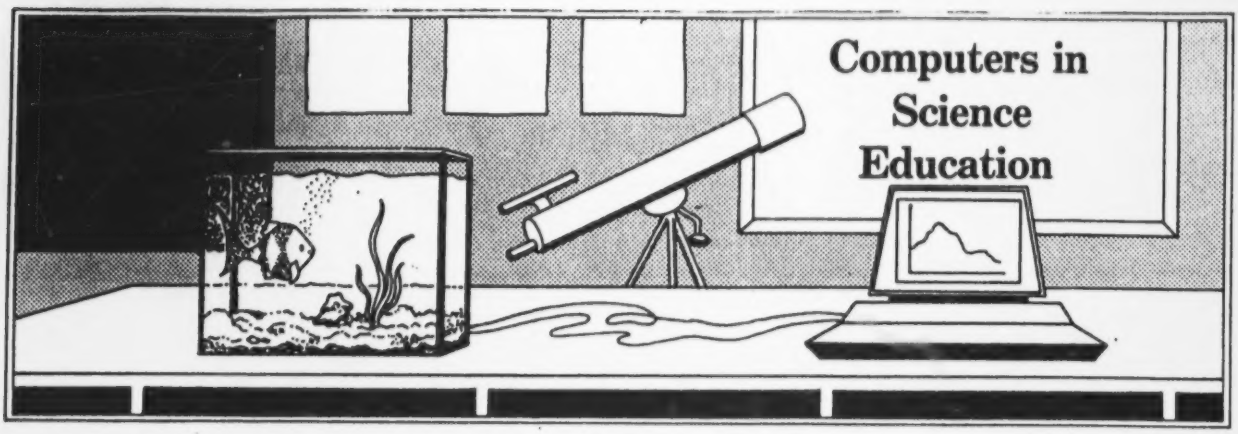
If the computer is providing data for student analysis, such as reporting the results of simulations under conditions specified by the students as a group, an entire class can use a single machine effectively to gather the data necessary for individual interpretations. Or students may enter their own data, as it is being collected through experimental inquiry, for computer analysis. Used in this way, the computer functions as does any other tool that must be shared in the science laboratory.

But some of this new "experiential" software is designed to be used by an entire class simultaneously, as the computer program calls the different student teams to work at the keyboard in turn. An example is the successful *Search* series of simulations in science and the social studies from McGraw-Hill. Many of the better educational game products can be used by groups of students at once, even though only one individual manipulates the controls. The Spinnaker *Snooper Troops* series, for example, requires mapping skills, communication skills, organized record keeping and the use of deductive logic—all of which are fundamental to process-centered science instruction.

Since much educational software currently on the market has been developed for use by individuals and requires significant amounts of time for completion, it is probably beneficial for students to complete such programs in teams of at least two. This will also encourage interaction. Such programs should be viewed as components within larger study units, which also require related student activities that are not computer based. Considered in this way, the computer can contribute to individualization of instruction, a concept espoused more frequently than it is practiced.

Since microcomputers will be increasingly more prominent in this new era of science teaching, it is important that available computer-based curriculum materials be evaluated critically. Allowing into the classroom science software with emphases that would be unacceptable in any other teaching medium introduces serious flaws into the curriculum. Teachers must vigorously resist the "that's all we have available in science" argument to justify the use of inferior software. More and more software that is inquiry-oriented and allows students to learn experientially is available for science and other content areas. Teachers must demand more of this high-quality software and reject outdated programs if computers are to become a valuable educational tool. ■

Odvard Egil Dyrli is the educational technology editor of Learning *magazine and a professor at the University of Connecticut, Storrs, Conn.*



The Computer in Science Education: Defining the Role of Technology

Michael R. Haney, Editor
Department of Computer and Information Science
University of Oregon
Eugene, OR 97403

Editor's Note: Mike Haney has eleven years' experience as a secondary science teacher and a Masters Degree in science education from the University of Maryland. He has been reviewing books and software for TCT for the last two years. He is completing his Ph.D. in computer education at the University of Oregon where he is examining the ways in which computers can be used to enhance the quality of science done in secondary schools.

The focus of this column will be on the uses for microcomputers in secondary science instruction, real and imagined. Reviews of useful literature and technology will also be given from time to time. The editor encourages science educators to submit articles and share ideas with other readers through this column.

Computers in science education seem inevitable. All the right preconditions are there. Science teachers are generally in tune with technology. Microcomputers are inexpensive compared to science equipment needed to stock a typical high school course. Student resistance to microcomputers is low, they seem to expect as much technology as the budget will allow. Yet, the microcomputer is chronically underused. Its role in the science classroom is more often as a deliverer of information rather than as a tool for inquiry. There is a danger that this misguided priority will move science education away from discovery and inquiry and toward content and structure. The initial direction educational computing takes may have lasting effects totally disproportionate with the thought and understanding that went into deciding that path. As classroom uses expand, the momentum of these early decisions will be hard to change. So before defining the role of the microcomputer in science education, we must examine the potentials of the microcomputer and reexamine the essential themes of science that are worth preserving.

The microcomputer has given all teachers potentials that many are just beginning to realize. The entire structure of education may change as the interfaces between courses, even between disciplines, blur. Through networks, teachers will gain access to large data banks that surpass local libraries. Textbooks are now available which include provisions for microcomputers. In mathematics, for example, publishers have put drills, problem sets and tests on diskettes suitable for various models of microcomputer. These can be changed or updated on a yearly basis. We can expect to see this move toward dynamic textbooks to continue and spread into the more promising areas of social studies and science. Special computer languages are available for educators. LOGO is the most notable, but PILOT is another example. At least five companies are selling special networking hardware for schools so micro-to-micro communication can take place. The possibilities exceed anything we now imagine, but one message is clearly emerging—computers will change education.

Science education is an excellent area to examine to learn what microcomputers can and should do. The best way to learn science is to do science. The microcomputer offers us a chance to do real science in the

science classroom. We can now reexamine the content and structure of our science courses without the technological limitations and financial constraints to which we have grown accustomed.

The basic themes of science should not only survive this new technology, they should be enhanced by it. Weaver is quoted, in the preface to *Investigating the Earth,* in a very appropriate and revealing description of science:

> Science is not technology, it is not gadgetry, it is not some mysterious cult, it is not a great mechanical monster. Science is an adventure of the human spirit. It is essentially an artistic enterprise stimulated largely by curiosity, served largely by disciplined imagination, and based largely on faith in the reasonableness, order and beauty of the universe of which man is a part.

The potential for computer misuse in science education is great. Since the computer is a tool of science, some teachers think whatever is done using the computer is also science. This illusion of science is even greater if what is being done with the computer is *about* science.

The Science Lab

Science education is uniquely not bound by content. Although it observes and describes nature, it is *how* it does this that is important. The study of science is the study of method. Consequently, it is assumed that science education will be laced with a heavy dose of lab experiences. Science is not so much an accumulation of what has been learned about nature as it is a method for examining it.

In a 1977 National Science Foundation report (NFS Report 78-72), I.R. Weiss reported that only 26% of high school science students have labs as often as once per week. This important experiential aspect of science education is slighted for a variety of reasons ranging from lack of equipment to an emphasis on testable basic skills. Furthermore, teachers showed a resistance to using any lab that was not prepackaged and ready to go. Innovation and updating of lab materials were rare. While some science educators would argue that science without experiments is not really science at all, many courses have evolved into teaching *about* science. Class time is spent on lectures, demonstrations and problem sessions. Sometimes students are asked to do independent work, but this is frequently nothing more than book research on a science topic.

There are many things that can go on in the science laboratory. The labs may not all be true experiments steeped in the "scientific method," nor should they be. In recent research I have been doing on currently-used science textbooks, I have found examples at all levels of labs which teach techniques, replicate historical experiments, introduce or clarify concepts, synthesize concepts, demonstrate ideas and raise questions. The rarest experience in the laboratory is the science experiment. Still, a few courses do amazingly well in emphasizing specialized brands of "inquiry." It is here in the laboratory that the microcomputer is potentially most powerful. It opens up to the student opportunities to do experiments that were never before possible. The speed, calculating power and extensibility of the microcomputer mean that the science classroom can emulate good science. By doing good science, the student will learn good science.

Although the ideal science experience may be real experimentation, schools function within artificial boundaries. Consequently, science classes offer a balance of text work, problems, lectures, demonstrations and readings in addition to lab experiences. The microcomputer should help to swing the balance in the direction of the experiment. Experiments are particularly valuable because they fill a gap which is often difficult for students to bridge. Through experiments, physical phenomena are interpreted with mathematics and translated into theory. Unfortunately, this is often done backwards; the experiment is used to demonstrate the theory—not to generate it. The microcomputer can help to expand the student's capabilities to formulate theories. Let's look at the steps in a typical experiment. The student:

- Identifies the parameters to be studied.
- Formulates a hypothesis, the relationship of these variables.
- Devises a systematic method of testing the hypothesis.
- Collects data.
- Interprets the data.
- Analyzes the difference between data and theory (error).
- Concludes, or revises the hypothesis and goes back to Step 3.

Of course, the type and scope of experiments is limited by time. The teacher must always ask if the concepts to be learned are worth the time required.

Analysis of Data with a Microcomputer

Data handling with a microcomputer is far different from hand processing of data. The speed and flexibility of this tool help the student do complex calculations very quickly. For example, students in life sciences are sometimes asked to find the growth rate of closed populations. Typically, this involves measuring the size of the population at different times. The variation in growth rates (measurements) make drawing conclusions difficult. Several groups may pool their measurements to normalize the data. To "discover" the growth rate, the student would probably make at least three graphs on quad paper and one on log paper. Assuming just 10 measurements were taken, this may require 30 calculations (A, A^2, A^3, 1/A, etc.) and 40 points to be plotted. The student can conceptualize this process quickly but the actual work is tedious. Here, the microcomputer is both a powerful tool and a relief. The stu-

dent can enter the data, do conversions and examine graphs in a matter of minutes.

Let's look at the above experiment more closely. For scientists it may be appropriate to enter numbers into a computer and have the best graph, equation and inflection points printed out. It is not appropriate for science education. The critical learning decisions must remain with the student. Not only should the computer not subvert these decisions, it should emphasize them. In this example, the student must first understand how the data is measured and how it is entered into the computer. If it is done through the keyboard, then there is no mystery. Second, the student should decide on the calculations to be done and should enter the method into the computer. If square inches must be converted into square centimeters, the student should make that decision and select the conversion. Finally, the graphing methods used should be chosen by the student. This includes the type of graph (cartesian, logarithmic, polar, etc.) and the scales. When the generated graph fits the student's criteria for acceptability, then that graph can be printed out.

In these computer enhanced experiments, the teacher plays an important role. An informed educator has decisions to make about the relative roles of the student and the microcomputer. If the computer is overprogrammed (by someone other than the student), it dominates and the student simply serves as a measuring extension for data. The experiences of collecting data, manipulating mathematics and reaching conclusions about the variables are all valuable. Tedious data processing contributes little to the student's understanding if it simply acts to prevent close analysis of the experiment.

Probably the most misunderstood aspect of experiments is error. Students give too little time and emphasis to this important factor in all true experiments. Error is something to be calculated and worked with; it indicates the significance of the results without which conclusions cannot be drawn. Too often, errors are treated as mistakes to be explained away. Knowing the precision and variance of the instruments, the student can always find just how much of the difference between the hypothesis and the results can be accounted for by the instruments and how much must be explained by other methods. The microcomputer will give the student both the time and the calculating power to find the uncertainty of the results. Now the student can appreciate the importance of each measuring instrument to the results. The often reported conclusion, "The experiment just doesn't work," would vanish. Instrument error and human error would become the only explanations.

The Microcomputer as Instrument

One of the most exciting uses of the microcomputer in science is as the primary lab instrument. Equipped with the proper accessories, the microcomputer permits experiments to be done that were formerly beyond the student's capabilities. Hardware suitable for high school students is now available, apparatus that will connect the microcomputer with other lab equipment. These peripherals interface the computer's digital soul with the analog world even it must live in.

Let's look at ways the computer can be used as a primary instrument, ways which extend the student's ability to experiment. The most interesting such research suitable for the high school level comes from Technical Education Research Centers. Also, the simple volume of literature and variety of hardware now available show that there is a lot happening in this field. Moreover, it is important to emphasize now that the computer and all of its peripherals should not become black boxes for the student to use. No matter how the microcomputer is used, the student should understand the function of each component.

Long term data collection is one of the first extensions that most teachers will think of. The microcomputer has the patience to perform a specific task with dedication. For example, a weather station could be monitored for unlimited periods; background radiation taken for days; or the temperature, humidity and radiation in a greenhouse recorded almost continuously. With a little imagination and some proven techniques, all these can be done without demanding the full attention of the microcomputer. They can each be run as a background program if the microcomputer has a real time clock with interrupts.

Extended data collection is only slightly more difficult. The speed of the microcomputer makes it ideal for collecting data in situations which transpire too quickly for humans. A few examples from the current literature include digitizing sound waves for later analysis; recording heartbeats in a form of electrocardiogram; multiple timing in motion experiments and measuring electric impulses from muscle tissues. In each of these cases, the process of collecting data is easily understood by the student; the microcomputer simply serves to lift some of the student's limitations.

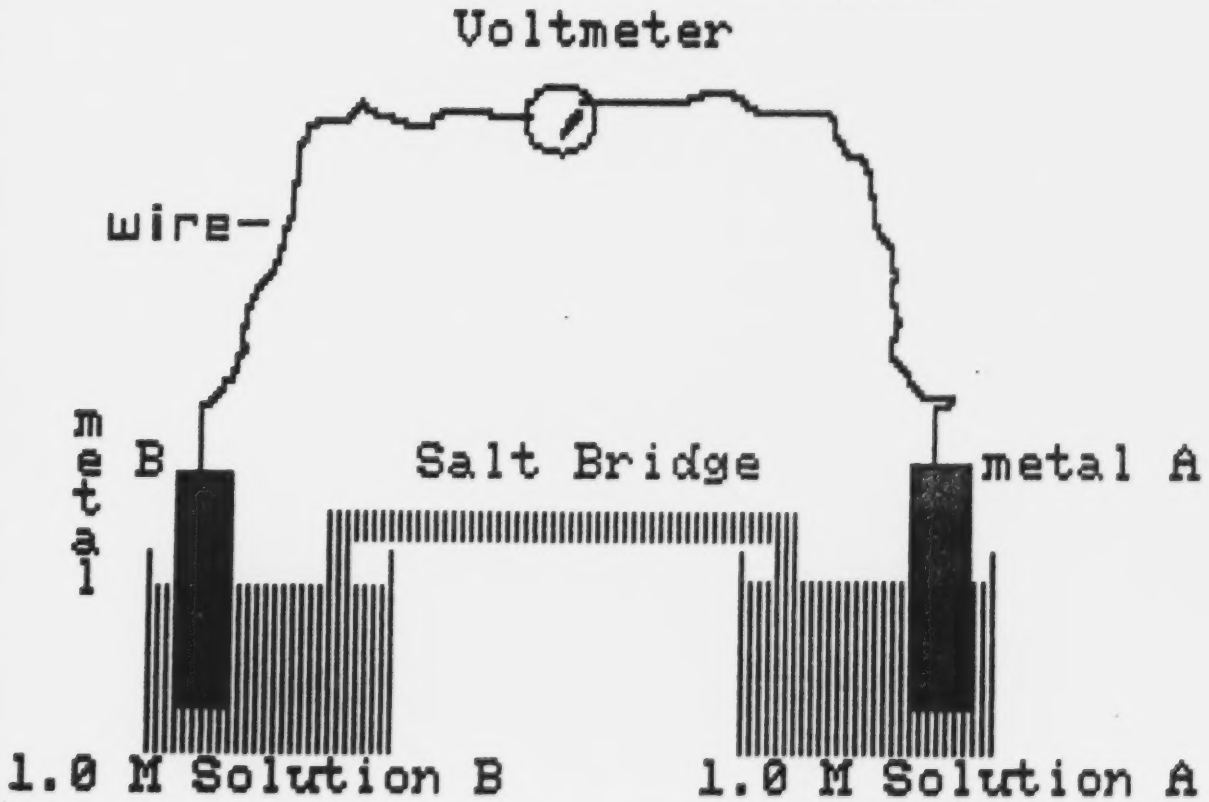
Other Uses in Science Education

The storage capacity of the microcomputer potentially makes it an excellent data library. Large data sets can be assimilated from different sources. This is often necessary in situations where repetitions of the same experiment significantly diminish error or where various lab groups are responsible for sets of overlapping data. Examples from traditional science courses include the ecological study of the decameter quadrant, the three-dimensional isothermal map generated for a classroom space, yearly earthquake data and long-term stream studies. In each of these cases, it is the accumulation and representation of the data which is cumbersome. The computer has been performing these functions for industry for years; the microcomputer makes the same capabilities affordable for the high school student.

Since Huntington II, the preponderance of science

software packages have been for simulations. Consequently, I unapologetically slight this topic here except to say that there is a danger of overuse. Simulations are extremely useful in situations where the concepts are fundamental but the real experiment is impractical. Unfortunately, there seems to be considerable interest in replacing science experiments with simulations, thus avoiding error and expense. It should always be remembered that science deals with observing nature and attempting to understand it. Frequently, natural phenomena are reduced or simplified in the laboratory; however, in the best situations, this process retains some semblance of reality for the student. Computer simulations are not nature, they are not seen as representing real world phenomena by the students and they represent a level of abstraction that is at least one level removed from the bridge we try to build within students in science education. Student generated simulations are a different matter. When the student simulates a natural phenomena or hypothesis on a computer, s/he develops the ability to abstract from the concrete, to represent the observable in logical form.

Until science educators grasp the power of the microcomputer as a tool for real science, microcomputers will continue to be both underused and misused in science education. For the microcomputer to be properly used in science requires the right hardware, educationally sound software, usable manuals and readable texts. But more than that, teachers are needed who know what it means to be science educated and not scientifically educated. END■



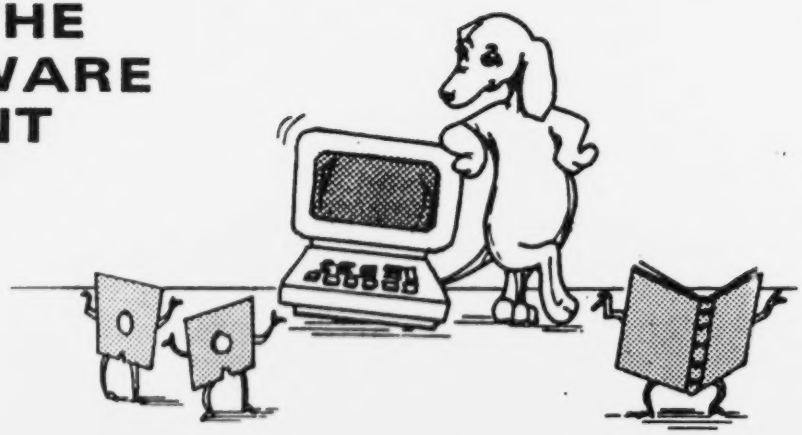
NATIONAL SCIENCE TEACHERS ASSOCIATION
TASK FORCE ON ASSESSING COMPUTER-AUGMENTED SCIENCE INSTRUCTION MATERIALS

microcomputer software evaluation instrument

VERSION 1983

TASK FORCE MEMBERS, 1982 - 1984
Leopold E. Klopfer, University of Pittsburgh, Chair
Gerald L. Abegg, Boston University
Mitchell E. Batoff, Institute for Professional Development
Jerry Doyle, Iowa Area Education Agency #16
Fred N. Finley, University of Maryland
Willis Horak, University of Arizona
Judith Keane, University of Chicago High School
Daniel Luncsford, Hammond (Indiana) High School
Vincent N. Lunetta, University of Iowa

GUIDELINES FOR USING THE MICROCOMPUTER SOFTWARE EVALUATION INSTRUMENT



This instrument should help you and your colleagues in examining and discussing the merits of a microcomputer software package intended to be used in science instruction. The instrument provides a sensible process and basic criteria for judging science software packages. It also lets you add criteria which educators in your particular school situation need to consider.

We are interested in evaluating the entire software package, which includes:

(a) the computer program,

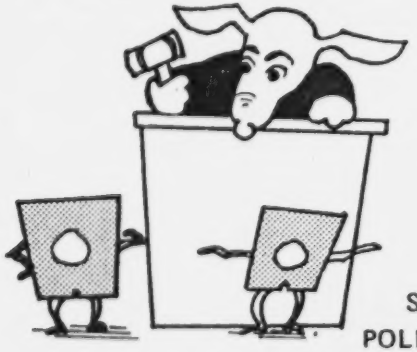
(b) any attendant student instructional materials which are not on the computer, and

(c) teacher's guide materials and/or program documentation.

The back page of the instument has a space where you can describe the components of the package you are examining, its science content and other characteristics.

The four sections of this instrument call attention to four important aspects of evaluating microcomputer software packages: Policy Issues, Science Subject Matter Standards, Instructional Quality, and Technical Quality. Each aspect should be rated separately, and the four section ratings can then be listed to give a profile for the software package. (A box for the profile is on the back page.)

Under each section of the instrument is a set of descriptive criteria pertaining to that aspect of evaluating software packages. Bipolar scales (with + and – values) are used to obtain the rating in each section, so the section ratings of a software package you are evaluating may turn out to be negative, zero, or positive. We (the Task Force members) think that an acceptable package should never have any negative rating in its profile. Probably you and the other educators at your school will want a software package to show strong positive ratings in its profile before you would accept it to be used in science instruction. The exact standard you set for acceptability of software packages should be decided on the basis of your local conditions and your educational good sense.

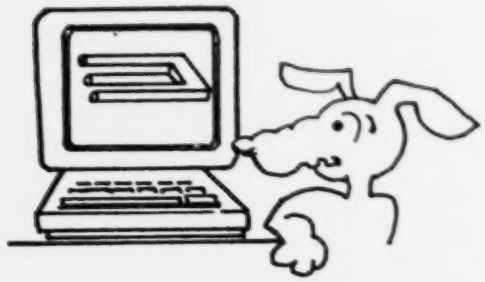


Section P
POLICY ISSUES

This section deals with the most difficult (and, we think, most important) questions that must be answered when any software package is being considered. These questions have to do with the appropriateness, compatibility, cost effectiveness (in both time and money), and instructional effectiveness of the software.

They include such concerns as these: Are the computer's special capabilities utilized to provide a learning experience not easily obtainable through other media? Does the computer program make good use of the student's time on the computer? Is the software package compatible with the goals and theoretical base of the school's instructional program? Does the computer encourage interaction among students while they are using it? What evidence is available that students attain the learning objectives of the software package? If you have other concerns of similar importance in your local situation, they should be added to the criteria of the Policy Issues Section.

Some people have suggested that, if a software package is seriously deficient on the criteria in the Policy Issues section, then it need not be given much further consideration. You should decide about this for your local evaluation process.



Section S
SCIENCE SUBJECT-MATTER STANDARDS

Good science instruction must present good science. To assure that science software packages meet this expectation, this section is concerned with the accuracy of science content, the sound application of science processes, the absence of stereotyping, and other issues related to the honest representation of science in instruction.

There is ample space in the section for adding (if you want to) subject matter criteria that are important in particular science areas.

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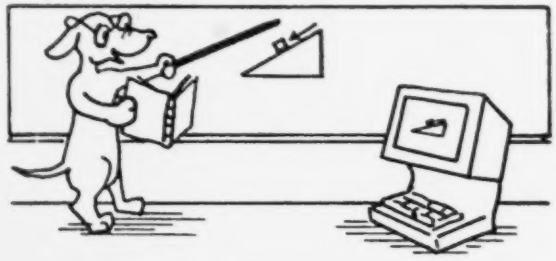
Section I
INSTRUCTIONAL QUALITY

This section is concerned with matters of effective pedagogy, application of good instructional design principles, adaptability of the software to students' individual differences, assessment of students' learning, and the role envisioned for the students using the software package. You should add any omitted criteria that you think are particularly important for good instruction.



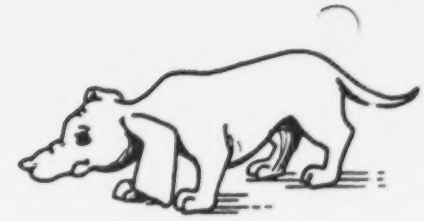
Section T
TECHNICAL QUALITY

The focus of this section is the technical quality of both the computer program and the other components of the software package. We are concerned with how well the computer program runs, how carefully its operational features are designed, and how well-designed the accompanying student and teacher materials are. Additional criteria may be needed here if you have particular computer hardware requirements or other expectations for a reliable software package.

MAKING YOUR RATINGS

Each section of this instrument contains a set of bipolar scales. (Any criteria you add should be constructed with similar scales.) You should carefully consider the descriptions at both ends of each scale and then assign a value on the −3 to + 3 scale according to how well the left or right description applies to the software package you are judging. Mark only one point on each scale. (If you cannot make a decision about a particular scale, mark the zero point for the scale.) To obtain the rating for each section, find the arithmetic sum of the values you assigned to all the scales in the section. You can enter the section ratings in the Software Package Profile box on the back page. The lower portion of the profile box should list the minimum standard you have determined for acceptability in each section. A comparison of the obtained ratings with the minimums can l ad to a recommendation concerning the suitability of the software package.

POLICY ISSUES



LEFT DESCRIPTION IS			Neither Description Applies	RIGHT DESCRIPTION IS		
Definitely True −3	Partly True −2	Slightly True −1	0	Slightly True +1	Partly True +2	Definitely True +3

The program makes the computer act as little more than a page turner or workbook.		The program exploits the computer's special capabilities (e.g., graphic animation, simulation) to provide a learning experience not easily possible through other media.
The program is wasteful of the limited time available for students to use the computer.		The program makes good use of the student's limited time on the computer.
The purpose and learning objectives of the software package are vague.		The purpose and intended outcomes of the of the software package are clearly defined.
The software package is in conflict with or irrelevant to the goals of the school's instructional program.		The software package is compatible with the the goals and theoretical base of the school's instructional program.
The program expects one student to work on the computer and not to interact with anyone.		Two or more students are encouraged to interact with one another while using the computer program.
There is little or no evidence that students attain the learning objectives of the software package.		The evidence that students attain the software package's learning objectives is convincing.
The software package is incompatible with the learning objectives and instructional materials of a current course.		The software package fits in well with other instructional materials already being used in particular courses or classes.
This software package's cost is exorbitant for what it delivers.		The total cost of this package is reasonable compared to its instructional value.

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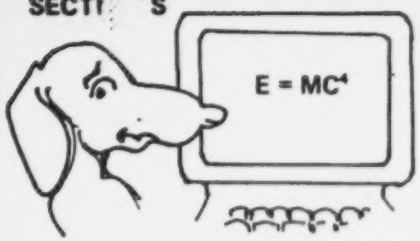
SECTI S



SCIENCE SUBJECT-MATTER STANDARDS

LEFT DESCRIPTION IS				RIGHT DESCRIPTION IS		
Definitely True −3	Partly True −2	Slightly True −1	Neither Description Applies 0	Slightly True +1	Partly True +2	Definitely True +3

The package presents topics which are irrelevant to the educational needs of the intended students.		The topics included in the package are very significant in the education of the intended students.
The science content is very inaccurate.		The science content is free from errors.
Racial, ethnic, or sex-role stereotypes are displayed.		The presentation is free of any objectionable stereotyping.
Biased or distorted information is paraded as factual information.		Well-balanced and representative information is presented.
The package includes science information which is greatly outdated.		The science content presented in the package represents current knowledge.
The presentation of the science content is confusing.		The science content is very clearly presented.
The package gives no attention to the processes of scientific inquiry.		Science inquiry processes are well-integrated into this software package.

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SEC ON I

INSTRUCTIONAL QUALITY

LEFT DESCRIPTION IS				RIGHT DESCRIPTION IS		
Definitely True −3	Partly True −2	Slightly True −1	Neither Description Applies 0	Slightly True +1	Partly True +2	Definitely True +3

The student is given very few choices that control how he/she works in the computer program's environment.		The program offers the student several options about the content to work on, the level of difficulty, and the rate of presentation.
The student using the program is passive and does little more than punch keys occasionally.		The student is actively involved in interacting with the computer's program.
The instructional strategies used in the computer program do not take pertinent research results into account.		The program's instructional strategies are based on relevant educational or psychological research findings.
The program cannot easily adapt to differences in students' ability, prior knowledge, or learning style.		The program has options which allow it to accommodate students' individual differences.
The software package fails to inform students about its learning objectives or the available activities.		Directions in the software package tell students where they will be going (objectives) and what they will be doing (activities).
The software package's instructional strategies and evaluation procedures ignore pertinent pedagogical principles.		The instruction used in the software package incorporates good sequences, motivating features, and evaluation procedures.
The software package expects that all students will attain the same level of achievement.		Students using the software package can experience success in attaining learning objectives at several levels of sophistication or difficulty.
The software package makes no provision for managing various instructional resources in a classroom.		The software package incorporates a management scheme for deploying available instructional resources.

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SECTION T

TECHNICAL QUALITY

LEFT DESCRIPTION IS				RIGHT DESCRIPTION IS		
Definitely True −3	Partly True −2	Slightly True −1	Neither Description Applies 0	Slightly True +1	Partly True +2	Definitely True +3

Students require an unacceptable amount of guidance by teachers to successfully operate the program.	Students can easily and independently operate the program after a modest period of orientation.
Feedback given by the program to student responses is inappropriate and confusing.	The program's feedback to student responses is appropriate, informative, and timely.
The program's graphics displays are crude and cluttered.	Graphics displays are crisp and clear.
The program's stance is callous and insulting.	The program is "user-sensitive."
The program has uncorrected "bugs" which cause it to behave inconsistently under certain circumstances or to "crash."	All possible combinations of user input and variable ranges are anticipated by the program, making its operation predictable and reliable.
Program documentation is incomplete, confusing, and inconsistent with the observed behavior of the program.	Program documentation is comprehensive, clear, and consistent with observed program behavior.
Student instructional materials *other than* the computer program are poorly organized, unattractive, and inappropriate.	Instructional materials *other than* the computer program are well-designed and appropriate for the students who will use them.
Teacher's materials in the software package are shabby, incomplete, and written in "hacker's" vernacular.	Teacher's guide materials are attractive, comprehensive, and suitable for the teacher-user who has little technical computer knowledge.
The software package is physically flimsy and easily sabotaged.	The package's components are designed to survive classroom conditions.

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Title of Software Package: _____

Publisher or Distributor: _____

Evaluators: _____

_____

SOFTWARE PACKAGE PROFILE

	P	S	I	T
RATINGS				
Minimum Standards				

Section P POLICY ISSUES
Section S SCIENCE SUBJECT-MATTER STANDARDS
Section I INSTRUCTIONAL QUALITY
Section T TECHNICAL QUALITY

Comments and Recommendations:

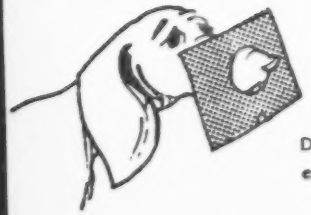
Software Package Description:
(Topics, program type, grade level, print materials for students, teacher guide)

Hardware Requirements:

The 1983 Version of this instrument was developed by our task force after more than a year of deliberation and discussion. The first draft was prepared by J.L. Fox and L. E. Klopfer, Learning Research and Development Center, University of Pittsburgh. The 1983 Version is our best current draft, which we expect to revise as computer technology and available software change.

We ask your help in preparing the next version. Information about your experience in using the instrument would be most helpful. Please send your comments and suggestions to:

Task Force on Assessing Computer-Augmented Science Instructional Materials
National Science Teachers Association
1742 Conneticut Avenue, NW
Washington, D.C. 20009



Additional copies of *Microcomputer Software Evaluation Instrument* are available from NSTA Publications.

Design & Illustration: Patricia Winstein Kelley
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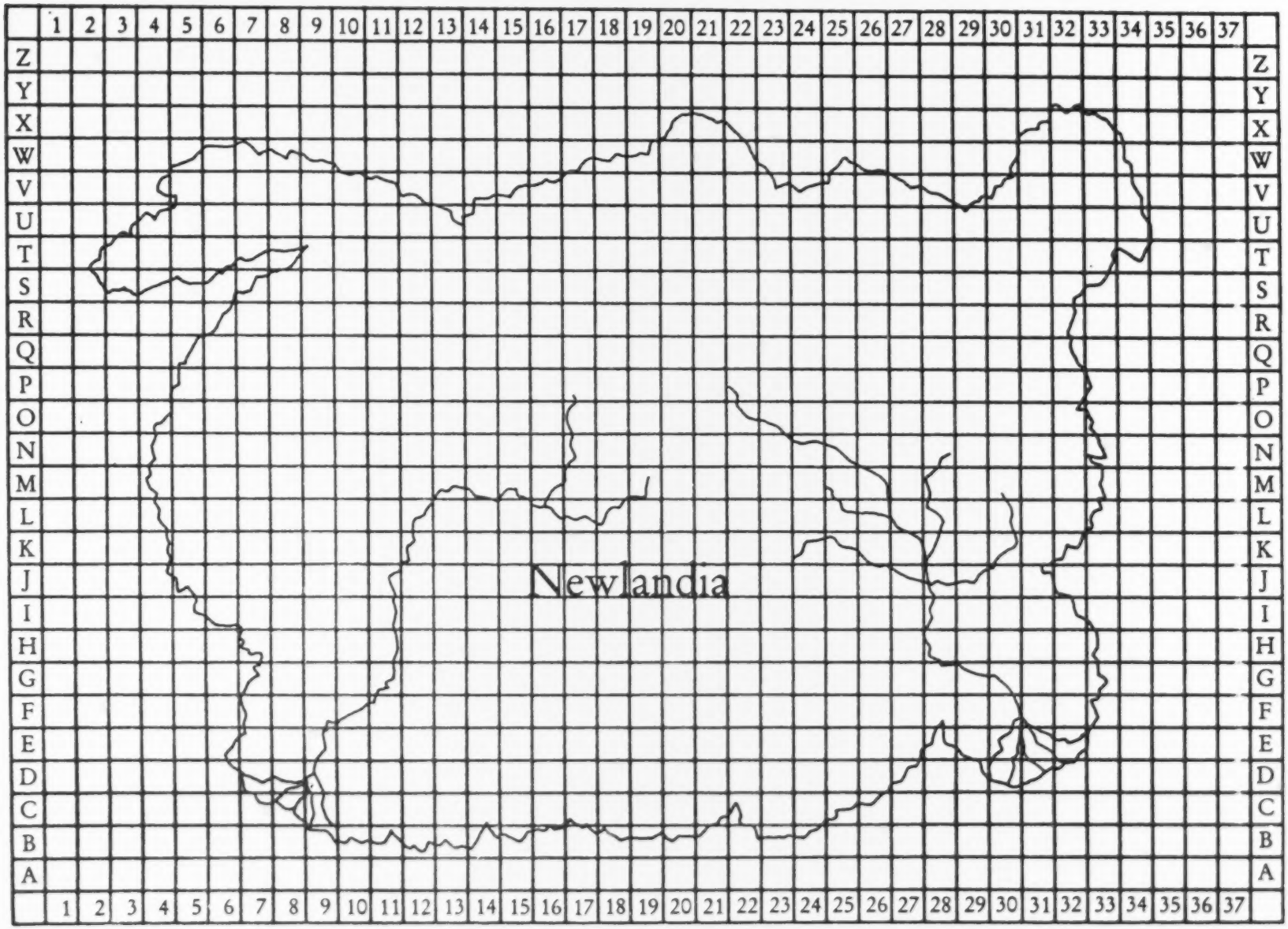
24 Map of Newlandia 60



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Company Records

Your company's name_____

Turn	The price of oil	Your oil reserves	Your company's money	Recently drilled wells	Your test location (letter, number)	Your test results
						nearby sedimentary rock
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

PROBLEM PAGE LAYOUT FOR SEMCALC

NAME: _____

DATE: _____

Brief statement of the problem. All relevant data are included.

INPUT DATA: drawn from above statement

RELATIONSHIPS: ratios which connect the data with each other and other know relationships

REQUIRED TO FIND: units and type of unit system for the answer

input datum	operation #1	operation #2	operation #n	output data
_____	_____	_____	_____	_____

a horizonal line beginning with input on the left and ending with the operations of output on the right

(use school letterhead if possible)

(date), 1984

(example vendor; get other addresses from Appendix C)

J & S Software
140 Reid Avenue
Port Washington, NY 11050

Dear Friends,

We are interested in obtaining a recent catalog of materials you may have to offer fro teaching science at the secondary level. We are particularly interested in software for the (your computer hardware type, including whether you use disk drives or cassette tapes or cartridges for loading programs).

Although we are particularly interested in (biloogical, physical, earth, general) science, we will appreciate prices and review policy on other types of science software and courseware.

If there have been reviews of your programs in national magazines, please provide these references. Under what conditions can we review the materials prior to purchase? Is your courseware of a nature to be integrated with existing curricula, or does it stand alone? What science process skills are taught?

Thank you for making your materials available to the science teachers of my school!

(your name under your signature)
(your school address and phone,
if not included on letterhead)

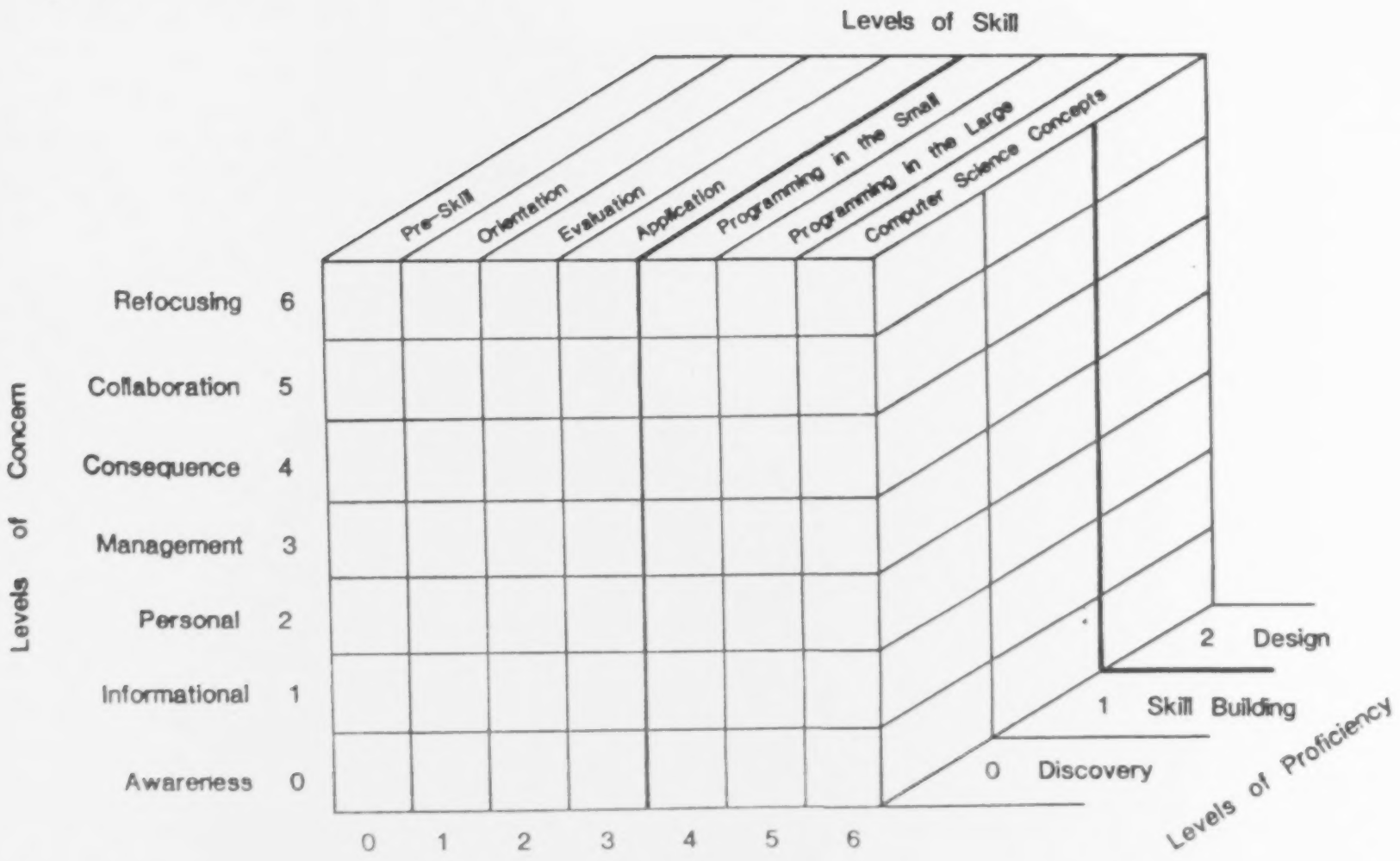
Supplementary Materials Packet

Included with this module is a packet of additional materials containing:

Sumburt's SemCalc video tape. This 30 minute tape of Judah Schwartz, Professor of Physics at the University of California-Irvine, describes the importance of semantic clues in solving written problems in science and math. The tape is to be used in the sixth session, PROBLEM SOLVING STRATEGIES AND INQUIRY.

Vendors' catalogs. These are to be used in the seventh session, CONCLUSIONS AND EVALUATIONS. The catalogs may be used as an example of the types of software sources available to science teachers.

TRANSPARENCY MASTERS



Taxonomy of Skills, Concerns, and Proficiencies

Input Interface

Needs definition

:acher training

Budgetary priorities

Parent involvement

Support Interface

Staff training and encouragement

Software / Courseware selection and integration

Hardware selection and maintainence

Internal Needs

Facilitator

teacher / paraprofessional

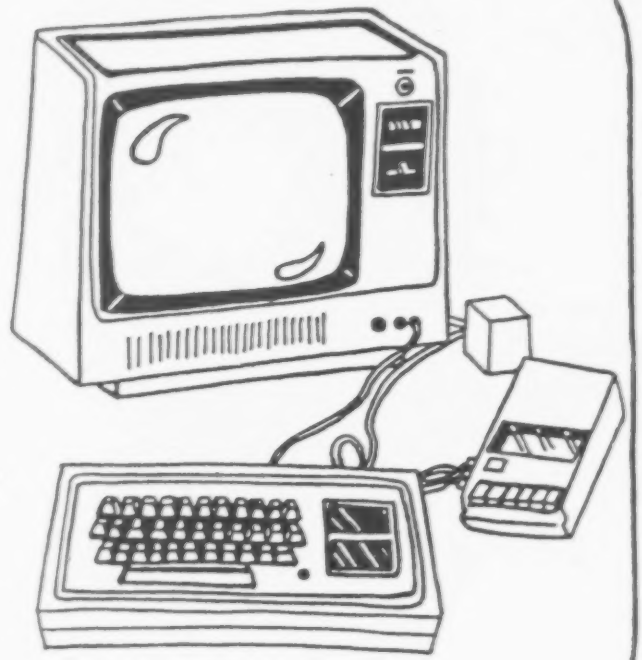
/ peer group

Computer & Peripherals

adaptability / expandability

Learners

require "after-class" access



Output Interface

desired competencies of learners

established by local school

T*2

Computer - Enhanced Learning Environment

LINE #	TIME	COST/OZ. (CENTS)
****	**********	*********
1	0	4
2	4.94	5
3	9.94	6
4	12.9	8
5	15.6	10
6	17.4	13
7	19.8	15
8	22.7	18
9	23.3	20

NUMERICAL ANALYSIS

FILE NAME: SAMPLE-POSTAL RATES SINCE 1958

X-AXIS DATA: TIME (YEARS)

Y-AXIS DATA: COST/OZ. (CENTS)

NUMBER OF DATA PAIRS = 9

SLOPE = .69

Y-INTERCEPT = 1.29

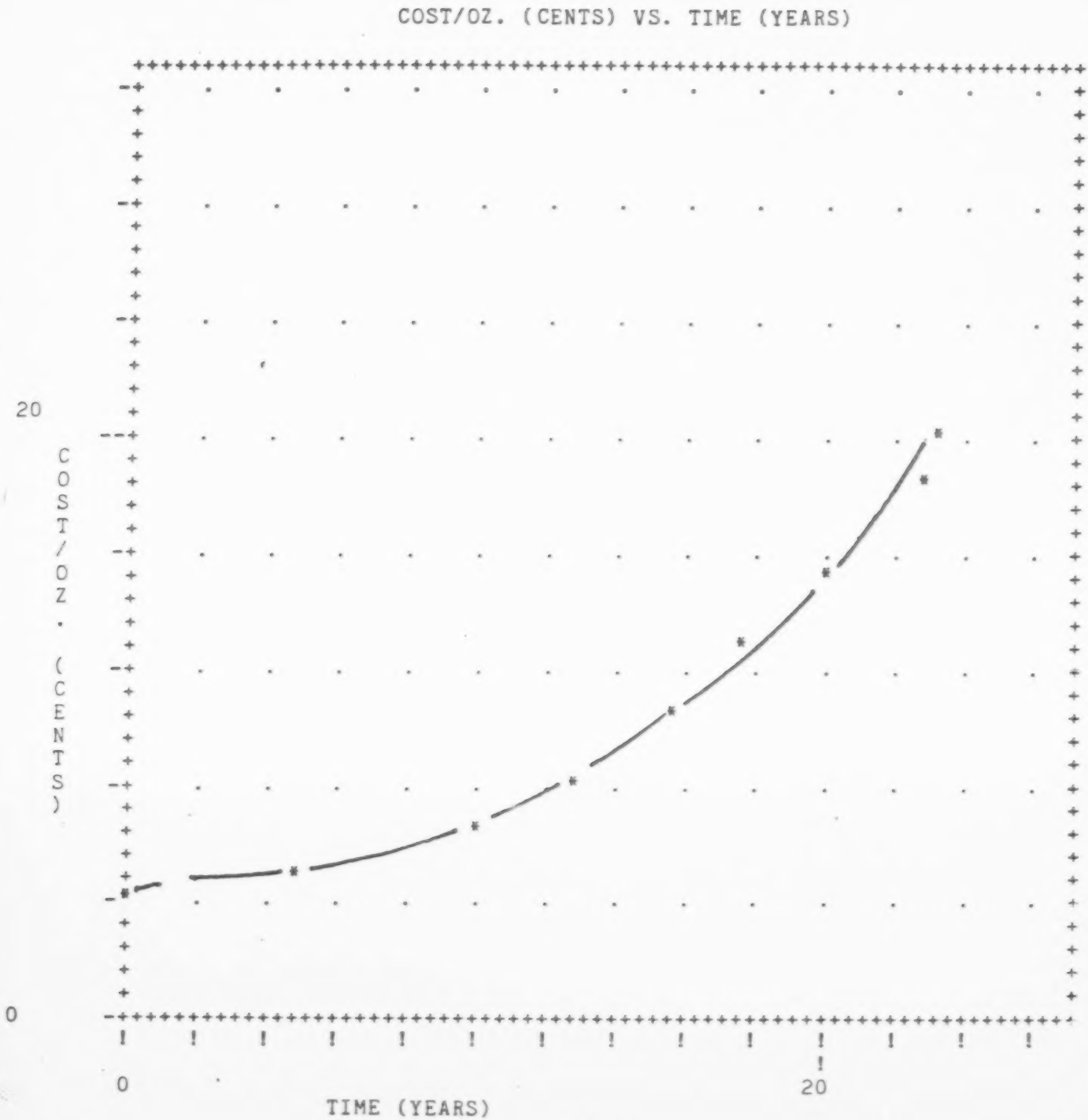
CORRELATION COEFFICIENT = .944

DO YOU WANT TO INTERPOLATE
OR EXTRAPOLATE (Y OR NO)
?Y
ENTER VALUE FOR HORIZONTAL AXIS VALUE
?30
THE VERTICAL AXIS VALUE IS 22

SAMPLE-POSTAL RATES SINCE 1958:

This data represents the cost of mailing a one-ounce letter through the U.S. Postal Service. The horizonal x-axis is time of each rate increase. The data was collected by Albert Bartlett and used in his article on exponential growth in *The Physics Teacher*, May 1982. For this time period the postal rate change was remarkably exponential. The graph can lead to interesting discussions of possible future postal rates.

FILE NAME: SWAP



T#4

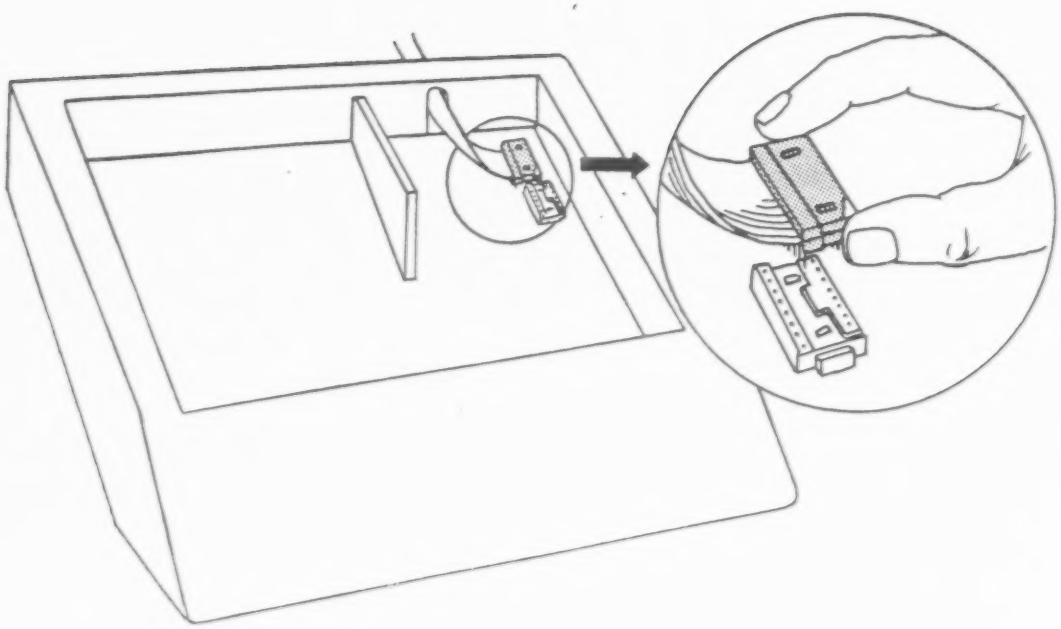


Figure 1.

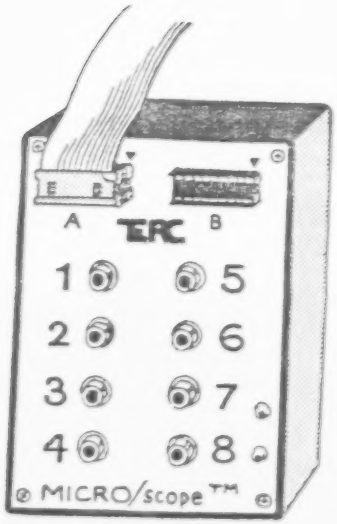


Figure 2.

A pine tree was 18 FEET tall at the beginning of the growing season. At the end of the season, it was 18 INCHES taller. How tall (in FEET) was it at the end of the season?

PS:

18 < RETURN >
FT < RETURN >
18 < RETURN >
IN < RETURN >

CTRL O A + B < RETURN >

SemCalc:

Can FT be converted to IN
or
can IN be converted to FT?

(YES or NO)

PS:

Y <RETURN>

SemCalc:

In order to proceed you must specify

A) How many FT in one IN
or
B) how many IN in one FT

ENTER A or B

CTRL O to start over

PS:

A <RETURN>

SemCalc:

How many FT in one IN?

PS:

1/12 < RETURN >

SemCalc:

18 FT + (18 * 1/12) FT =

19.5 FT

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

T#6

Marie-Francoise and Maria Francesca went on a bicycle trip of 840 MILES. During the week they were on the road, they spent a total of 60 HOURS actually riding. What was their average speed in MILES PER HOUR?

PS:

840 < RETURN >
MI < RETURN >
60 < RETURN >
HR < RETURN >

CTRL O A / B < RETURN >

SemCalc:

EVALUATING

840 MILES

DIVIDED BY

60 HOURS

PRESS ANY KEY TO CONTINUE

PS: <RETURN>

SemCalc:

THE UNITS OF THE ANSWER ARE

$$\frac{\text{MI}}{\text{HR}}$$

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

840 MI / 60 HR =

$$14 \frac{\text{MI}}{\text{HR}}$$

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

See what happens if you divide 60 HR by 840 MI!

T#7

A large water storage tank is leaking at the rate of 84 GALLONS/HOUR. If you assume that it took 4 HOURS to reach this rate of water loss, how fast did the rate of loss change?

PS:

84 < RETURN >
GAL/HR < RETURN >
4 < RETURN >
HR < RETURN >

CTRL O A / B < RETURN >

SemCalc:

EVALUATING

84 GAL/HR

DIVIDED BY

4 HR

PRESS ANY KEY TO CONTINUE

PS: <RETURN>

SemCalc:

THE UNITS OF THE ANSWER ARE

$$\frac{\text{GAL}}{\text{HR HR}}$$

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

84 GAL/HR / 4 HR =

$$21\ \frac{\text{GAL}}{\text{HR HR}}$$

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

Try multiplying 84 GAL/HR by 4 HR and see what happens!

If a large bookkeeping job takes

12 PERSONS a total of 2 MONTHS to do
8 PERSONS a total of 3 MONTHS to do
6 PERSONS a total of 4 MONTHS to do
4 PERSONS a total of 6 MONTHS to do
3 PERSONS a total of 8 MONTHS to do
2 PERSONS a total of 12 MONTHS to do

can you think of a way of describing how large a job it is?

PS:

6 < RETURN >
PERSON < RETURN >
4 < RETURN >
MONTH < RETURN >

CTRL O A * B < RETURN >

SemCalc:

EVALUATING

6 PERSON

MULTIPLIED BY

4 MONTH

PRESS ANY KEY TO CONTINUE

PS: <RETURN>

SemCalc:

THE UNITS OF THE ANSWER ARE

PERSON MONTH

PRESS CTRL O TO START OVER

PRESS ANY KEY TO CONTINUE

PS:

< RETURN >

SemCalc:

6 PERSON * 4 MONTH =

24 PERSON MONTH

PRESS ANY KEY TO CONTINUE

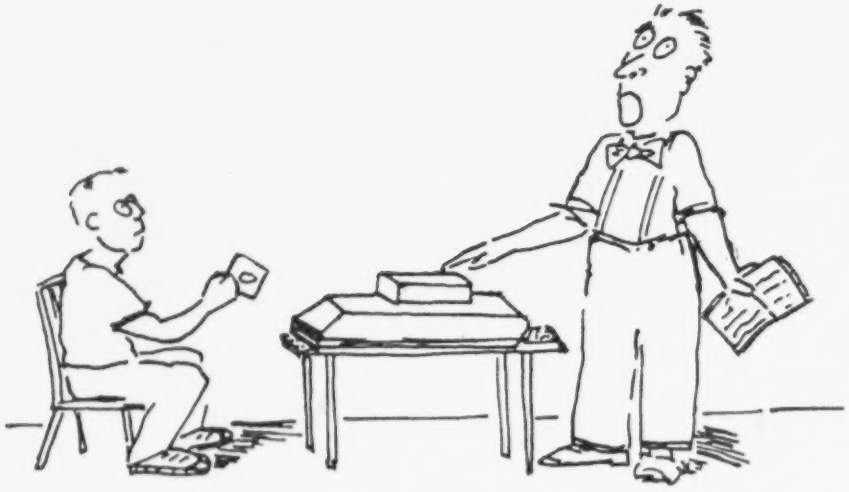
PS:

< RETURN >

T#9

DRILL AND PRACTICE

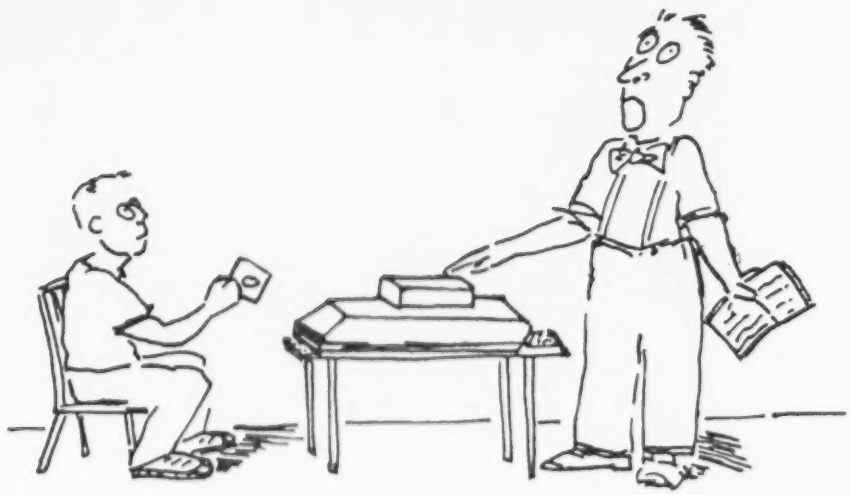
- Tailors instructions to individual
- Provides for random selection
- Gives immediate reinforcement



Teacher	Computer	Student
• SELECTS MATERIAL	• PRESENTS MATERIAL	• INTERACTS WITH COMPUTER
• MATCHES INSTRUCTION TO STUDENT	• RECORDS STUDENT PROGRESS	• SEES RESULTS
• CHECKS PROGRESS		

TUTORIALS

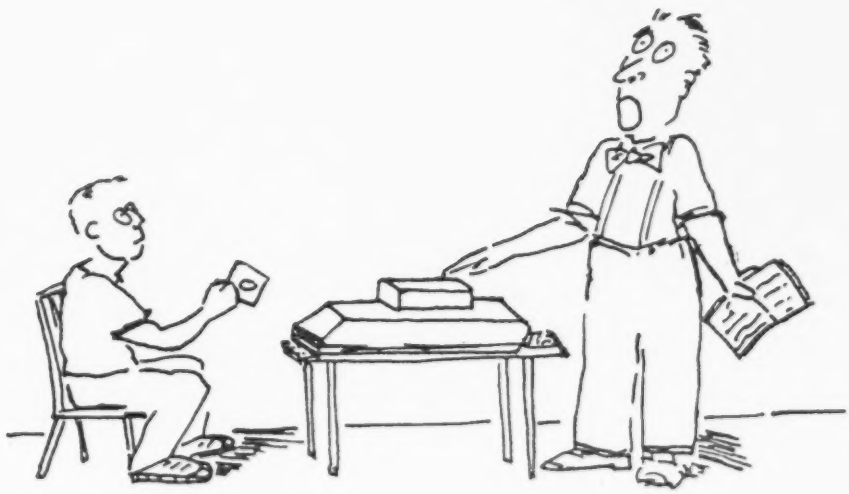
- Tailors instruction to individual
- Introduces new concepts
- Gives immediate reinforcement



Teacher	Computer	Student
• SELECTS MATERIAL	• PRESENTS MATERIAL	• INTERACTS WITH COMPUTER
• ADAPTS INSTRUCTION	• MONITORS RESPONSES	• SEES RESULTS
• MONITORS PROGRESS	• KEEPS RECORDS	

SIMULATIONS

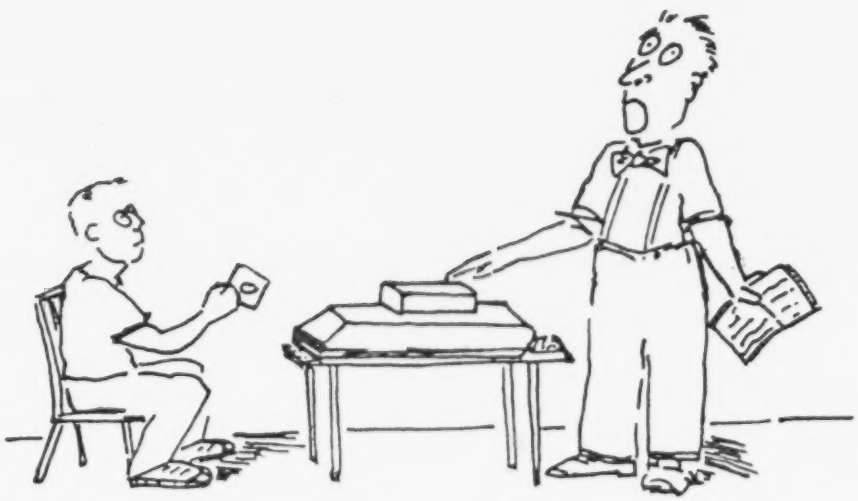
- Approximates real events
- Compress years into minutes
- Tests hypotheses



Teacher	Computer	Student
• INTRODUCES THE SUBJECT	• PLAYS ROLE	• EVALUATES DECISIONS
• GIVES BACKGROUND	• DELIVERS RESULTS OF DECISIONS	• MAKES CHOICES
• GUIDES DISCUSSION		• DISCUSSES RESULTS

EDUCATIONAL GAMES

- Motivates
- Develops logical guessing
- Presents basic facts in new ways

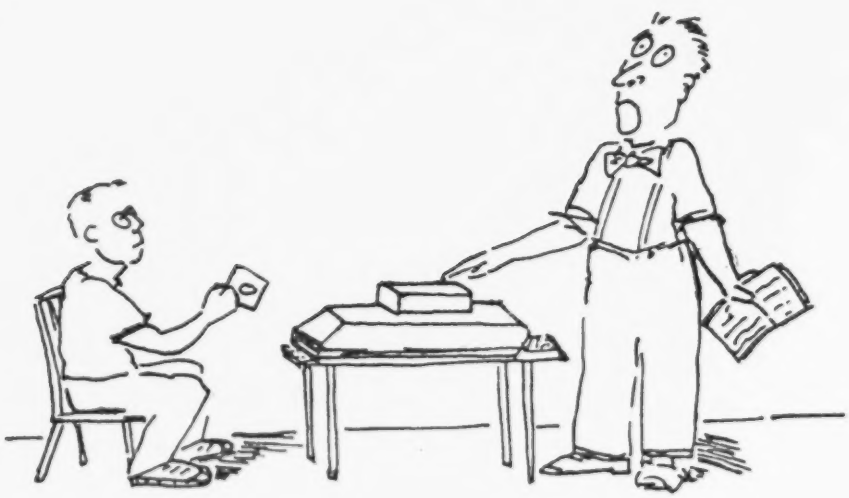


Teacher	Computer	Student
• SETS LIMITS	ACTS AS:	• LEARNS STRATEGY
• DIRECTS PROCESS	• COMPETITOR • JUDGE	• EVALUATES CHOICES
• MONITORS RESULTS	• SCORE KEEPER	• COMPETES WITH COMPUTER

T#13

PROBLEM SOLVING

- Works with data
- Systematizes information
- Performs rapid calculations



Teacher	Computer	Student
• ASSIGNS THE PROBLEM	• PROCESSES THE DATA	• DEFINES THE PROBLEM
• CHECKS RESULTS	• PROVIDES ANSWERS	• SETS UP THE SOLUTION

T#14

MATERIALS GENERATION

- Produces:
  worksheets
  answer sheets
- Saves teacher time

Teacher	Computer	Student
• SELECTS MATERIAL	• CONFIGURES DATA	• USES MATERIALS GENERATED
• ESTABLISHES DESIGN PARAMETERS	• PRINTS OUT RESULT	

A

Representative Science Courseware

The following listing of courseware for science is taken from the *Classroom Computer Learning*, Vol 4, No. 5: *DIRECTORY OF NEW EDUCATIONAL COMPUTER SOFTWARE* Winter, 1983-84, copyright Pitman Learning, Inc. The entire directory sells for $9.95, and is available from Pitman Learning Inc., 19 Davis Drive, Belmont, CA 94002. In addition to science, it lists extensive software written since September, 1982, for language arts and English, mathematics, social studies, the arts, general problem solving, foreign languages, vocational and business education life skills, computer literarcy and languages, authoring systems, tools, classroom management, and testing and guidance. A directory of publishers is provided, along with an index to software by computer.

To order any of these materials, you must write directly to the publisher whose name is printed in boldface type after the description of each software listing.

3. Science

Biology

3.1 All About Dinosaurs
The sizes and shapes of giant reptiles are compared through computer graphics. Students also see what life was like when dinosaurs lived. (Grades 1–4.)
Orange Cherry Media. *Disk; Apple II series (48K): $34.00. Disk or two cassettes; Commodore PET (16K); TRS-80 I, III, 4 (16K); Atari 400, 800, 1200 (24K or 16K); disk, $34.00; cassettes, $28.00 or $15.00 each.* (NP)

3.2 Anatomy Quiz: Muscles of the Body
Thousands of questions are posed about the muscles of the human body with answers in multiple choice and matching. For students in medical and allied fields. (Grades 9 and above.)
Professional Computerware. *Disk; Apple II series (48K): $19.95.* (NP)

3.3 Animal Facts
This series is an introduction to the world of animals. Science knowledge is stressed as well as reading and listening skills. Features include menu format, graphic reinforcement, random questions and self-scoring. (Grades 1–6.)
Aquarius. *Two disks; Apple II series (48K); TRS-80 III (32K): $55.00. Two cassettes; TRS-80 I, III (32K): $45.00.* (P)

3.4 The Biology Test Maker
Designed to help teachers develop biology quizzes and tests from a bank of almost 900 multiple-choice questions. Tests can be printed, modified or mixed. (All grades.)
J & S Software. *Four disks; Apple II series (48K): $75.00.* (P)

3.5 Birds
An overview that tells why birds are important, how they are born, what makes them birds and other information. Retention of material is tested in a game. (Grade 4.)
Right On Programs. *Disk; Apple II series (48K): $18.00. Disk or cassette; Commodore 64 (64K), PET (32K): $18.00.* (NP)

3.6 Body Awareness
Teaches parts of the body. Students learn positions of body parts, match words to body parts and match clothes to parts of the body. Three games in one. (Preschool and above.)
Learning Well. *Disk; Apple II series (48K): $49.95.* (P)

3.7 Body Basics
A program that associates body parts with their names through bright colors, sound and music. (Preschool.)
Dynacomp, Inc. *Disk; Atari 400, 800, 1200 (48K); joystick: $18.95.* (NP)

3.8 Body Systems Series
A menu-driven, interactive four-program series that studies the respiratory, digestive, bone and muscular, and circulatory systems. Includes mini- and review quizzes and automatic branching to remedial instruction. (Grades K–6.)
Marshfilm Enterprises, Inc. *Four disks; Apple series (48K); monitor: $135.00 per series; $39.95 per program.* (P)

3.9 Cell Growth and Mitosis
A courseware package designed for any science curriculum that includes study of living systems. Color graphics show the detailed process of cell division, beginning with a thorough analysis of why a cell divides. Simulations demonstrate chromosomal replication and the concept of surface area/volume ratio. (Grades 8 and above.)
Classroom Consortia Media, Inc. *Disk; IBM PC/XT (128K): $69.95.* (NP)

3.10 Classify
A student-interactive simulation that allows students to develop classification keys for living organisms. By looking for patterns, grouping characteristics appropriately and assigning correct labels, the student develops an understanding of the underlying logic of classification keys. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $70.00.* (NP)

3.11 Coexist Apple: Population Dynamics
A software package designed to teach students, through simulation, biological situations that affect population growth. (Grades 9 and above.)
Conduit. *Disk; Apple II series (48K): $40.00.* (NP)

3.12 Compete Apple: Plant Competition
This simulation enables students to plan and carry out investigations of interactions between flowering plants. (Grades 9 and above.)
Conduit. *Disk; Apple II series (48K): $40.00.* (NP)

3.13 Dicross
A student-interactive program that simulates various dihybrid genetic crosses. This unit reinforces the understanding of concepts presented in *Monocros* and provides an introduction to dihybrid Mendelian genetics. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $70.00.* (NP)

3.14 Digestive and Reproductive Systems
This three-subject, 12-lesson program provides practice in identifying the parts, terms and functions of the digestive and reproductive systems. It includes a test and vocabulary review. (Grades 5 and above.)
Centurion Industries, Inc. *ROM cartridge; Versator Educational Computer (48K): $59.50.* (P)

3.15 DNAgen
An interactive program that simulates the functioning of DNA and the genetic code. By systematically varying input sequences, students can investigate the genetic code, specific coding patterns and the effects of mutations at the molecular level. (Grades 9 and above.)

Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $60.00.* (NP)

3.16 The Ear

A functional graphic of the outer and inner ear described in both common and Latin terms. (Grades 5 and above.)
Micro Power and Light Company. *Disk; Apple II series (32K): $24.95.* (P)

3.17 Elementary Biology

A drill-and-practice program pertaining to biological food chains and the circulatory system. (Grades 1–9.)
Minnesota Educational Computing Consortium. *Disk; Atari 400, 800 (48K): $38.00.* (NP)

3.18 Elements of Medical Terminology

A drill-and-practice course in medical/anatomical terminology. Twenty-one lessons train students to recognize terms by assembling prefixes, suffixes and combining forms. The program tracks up to 100 students concurrently. (Grades 8 and above.)
Applied Microsystems, Inc. *Disk; Apple II series (48K); Franklin (48K): $40.00.* (NP)

3.19 Evolut Apple: Evolution and Natural Selection

This simulation helps students develop a conceptual understanding of how selection controls fluctuations in gene frequencies of wild populations, thus producing adaptation for specific requirements of the environment. (Grades 9 and above.)
Conduit. *Disk; Apple II series (48K): $40.00.* (NP)

3.20 Flow of Heart

A program on the flow of blood through the human heart. (Grades 7–12.)
Robbinsdale Computer Project. *Disk or cassette; Commodore PET (8K): $9.95.* (P)

3.21 Flygen

An interactive simulation of drosophila genetics. Students make simulated monohybrid or dihybrid crosses with any of 25 common varieties of the fruit fly. The program includes dominance, sex linkage, chromosomal linkage, back or test cross capability, plus a degree of random error in the results. (Grades 9 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $60.00.* (NP)

3.22 Hardy-Weinberg

Asks the student to enter observed and expected values. The computer then solves the Hardy-Weinberg equation. (Grades 7–12.)
Computer Courseware Company. *Disk or cassette; Apple II series (48K); TRS-80 I, III 4 (32K or 16K); VIC 20 (5K); Commodore 64 (64K): $15.00.* (NP)

3.23 Heartbeat/ Heartwork/Heartflow

A program about the heart and the systems that relate to it. The high-resolution screen displays blood flow, a heart-saver game, quizzes and illustrations. (Grades 6 and above.)
J & S Software. *Disk; Apple II series (48K): $39.95.* (P)

3.24 Heart Parts

A program in which students determine the parts of the human heart. (Grades 4–8.)
Robbinsdale Computer Project. *Disk or cassette; Commodore PET (8K): $9.95.* (P)

3.25 Idgame

This identification game allows students to practice strategies for identifying organic compounds. The program is based on a data base of 41 test results for 33 organic compounds. (Grades 12 and above.)
Conduit. *Disk; Apple II series (48K); TRS-80 III (32K): $75.00.* (NP)

3.26 Internal Journey

This simulation adventure takes students inside the human body as they follow the incredible journey food takes through the digestive process. Along the way they discover how the digestive organs work together to break down carbohydrates, proteins, fats, vitamins and water. (Grades 8 and above.)
Walt Disney Personal Computer Software. *Disk; Apple II series (48K); Atari 800 (32K): $75.00.* (P)

3.27 Introductory Genetics

A five-part program on heredity, monohybrid and dihybrid crosses, sex determination, probabilities and in breeding. Student lab booklets included. (Grades 7 and above.)
Educational Materials & Equipment Company. *Two disks; Apple II series (48K): $85.00.* (P)

3.28 Leaf: Structure and Function

A courseware package designed for any general science and biology curriculum. Students explore the role of the leaf as "chemical factory" of the plant. (Grades 8 and above.)
Classroom Consortia Media, Inc. *Disk; IBM PC/XT (128K): $69.95.* (NP)

3.29 Life in the Oceans

An explanation of why the oceans and ocean life are so important to survival. Animals, fish, birds, mammals and weather are discussed. A game is included. (Grade 3.)
Right On Programs. *Disk; Apple II series (48K): $18.00. Disk or cassette; Commodore PET (32K), 64 (64K): $18.00.* (NP)

3.30 Linkover Apple: Genetic Mapping

This simulation allows students to plan and execute a program of mapping experiments so that they can then draw an accurate genetic map of a single chromosome. An important part of the package is the challenge it affords students in planning genetic crosses themselves. (Grades 9 and above.)
Conduit. *Disk; Apple II series (48K): $40.00.* (NP)

3.31 Living Things

A brief look at the living things that exist on earth—plants, people and animals—and how we live together. Simple questions and a matching game complete the program. (Grades 2.)
Right On Programs. *Disk; Apple II series (48K): $18.00. Disk or cassette; Commodore 64, PET (32K): $18.00.* (NP)

3.32 Mammals

Discusses animals in general and mammals specifically. A game tests students' retention of material. (Grade 4.)
Right On Programs. *Disk; Apple II series (48K): $18.00. Disk or cassette; Commodore PET, 64 (32K): $18.00.* (NP)

3.33 Meiosis

An interactive simulation of gamete formation, with four options. An extensive review and student lab booklets accompany the program. (Grades 7 and above.)
Educational Materials & Equipment Company. *Disk; Apple II series (48K): $45.00.* (P)

3.34 Microbiology Techniques

A five-part program on using pipets, dilutions, bacteria growth, graph generation and diagnostic identification procedures. Accompanied by student lab booklets. (Grades 7 and above.)
Educational Materials & Equipment Company. *Disk; Apple II series (48K): $45.00.* (P)

(continued)

3.35 Monocros

A student-interactive program that simulates various monohybrid genetic crosses. Students learn the concepts of phenotype, genotype, dominance and test cross. This program provides an introduction to basic Mendelian laws. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $70.00.* (NP)

3.36 Moths

A student-interactive simulation based upon the historical occurrence of peppered-moth evolution in industrial England. Students learn the concepts of selection, mutation, gene pool, gene frequency and the Hardy-Weinberg principle. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $70.00.* (NP)

3.37 Natural Selection

A three-part program about the effects of selection on gene frequencies, evolution, and about the effects of industrial pollution on a moth population. Student lab booklets accompany the program. (Grades 7 and above.)
Educational Materials & Equipment Company. *Disk; Apple II series (48K): $40.00.* (P)

3.38 Number 5,000 Body Systems Series

Provides a study of the respiratory, digestive, circulatory, bone and muscular systems. It employs frequent student response, quizzes, automatic branching to remedial instruction, dictionary of new terms, optional sound and animated graphics. (Grades K-6.)
Marshfilm Enterprises, Inc. *Four disks; Apple II series (48K): $135.00 per set; $39.95 per disk.* (NP)

3.39 Osmo

A student-interactive simulation that explores various osmotic conditions in red blood cells. Students develop an understanding of diffusion, osmosis, permeability and equilibrium. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $70.00.* (NP)

3.40 Passive Transport

A courseware package designed for any science curriculum that includes study of biological systems. Graphics and real-time animated simulations illustrate the processes of diffusion and osmosis. Includes interactive experimentation with the concepts of molecule and pore size. (Grades 8 and above.)
Classroom Consortia Media, Inc. *Disk; IBM PC/XT (128K): $69.95.* (NP)

3.41 Photosynthesis and Light Energy

A courseware package designed for any science curriculum that includes study of living systems. Topics covered are light as energy for plants, variables and controls, characteristics of light and wavelengths of light used by the chloroplasts. Includes animated simulations and color graphics. (Grades 8 and above.)
Classroom Consortia Media, Inc. *Disk; IBM PC/XT (128K): $69.95* (NP)

3.42 Plant

A students-interactive simulation that explores the relationship of light intensity and light duration to the growth and development of a green plant. The students develop problem-solving skills and measure, tabulate and graph plant growth. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $70.00.* (NP)

3.43 Plant Growth

A courseware package designed for any science curriculum that includes study of plant anatomy and physiology. Color graphics and simulations illustrate growth from seed to plant. Students study hormone control, feedback mechanisms, transport and differentiation. (Grades 8 and above.)
Classroom Consortia Media, Inc. *Disk; IBM PC/XT (128K): $69.95.* (NP)

3.44 Plants and How They Grow

Basic introduction to plants, showing the parts of plants and trees, what each part does and how seeds are carried to reproduce. A game is included. (Grade 2.)
Right On Programs. *Disk; Apple II series (48K): $18.00. Disk or cassette, Commodore 64, PET (32K): $18.00.* (NP)

3.45 Popgen

An interactive program based on the Hardy-Weinberg law and the complex concept of genes in populations. Students may investigate the effects of selection, small population size, migration pressures and other factors biologists consider important in the evolution of organisms. (Grades 9 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $60.00.* (NP)

3.46 Popgro

An interactive program that permits students to explore population growth and progressive refinement of scientific models. Students may manipulate pertinent variables and observe the outcome on a population, providing experience in interpretation of data. (Grades 9 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $60.00.* (NP)

3.47 Predation

Two simulations students can use to study predator-prey interaction. Both programs show the differential equations and the parameters that define the model. Growth curves, based on parameters selected by students, are then graphed on both a time and a phase plot, so that students can observe how changes in the parameters are automatically reflected by changed curves. (Grades 12 and above.)
Conduit. *Disk; Apple II series (48K): $50.00.* (NP)

3.48 Prepared Exams: Cells

A 20-question multiple-choice exam that covers topics from cell composition to microscope use. Questions cover such topics as the nucleus, mitosis-meiosis, RNA-DNA and tissues. Requires program *Exam Options* in order to operate. (Grades 9–12.)
Computer Applications Tomorrow. *Cassette, TRS-80 I, III (16K): $11.95.* (NP)

3.49 Prepared Exams: Life Systems

A 20-question multiple-choice exam covering life systems. Includes questions about sexual reproduction, conjugation, budding and body functions. Requires the program *Exam Options* in order to operate. (Grades 9–12.)
Computer Applications Tomorrow. *Cassette, TRS-80 I, III (16K): $11.95.* (NP)

3.50 Prepared Exams: Plant Life

A 20-question multiple-choice exam. Includes questions about germination, transpiration, respiration and spores.

Requires the program *Exam Options* in order to operate. (Grades 9–12.)
Computer Applications Tomorrow. *Cassette; TRS-80 I, III (16K): $11.95.* (NP)

3.51 **Respiratory and Nervous System**
This three-subject, 12-lesson module provides practice in identifying the parts, terms and functions of the respiratory and nervous systems. It includes a summary test and vocabulary review. (Grades 5 and above.)
Centurion Industries, Inc. *ROM cartridge; Versator Educational Computer (48K): $59.50.* (NP)

3.52 **Science— The Human Body: An Overview**
An introductory science course that contains eight computer programs to help students learn how the main body systems work. Lessons cover muscular, digestive, respiratory, skeletal, circulatory and nervous systems. Includes a review test. (Grades 6 and above.)
BrainBank, Inc. *Two disks or cassettes; Apple II series (48K), Commodore PET (16K): $90.00.* (P)

3.53 **Science— The Skeletal System**
This follow-up to *The Human Body* series contains five programs that explain the skeletal system in detail. (Grades 6 and above.)
BrainBank, Inc. *Two disks or cassettes; Apple II series (48K), Commodore PET (16K): $70.00.* (P)

3.54 **Science: The World Around Us**
Four games designed to help students learn terms and concepts from the biological and physical sciences. In *Science Concepts, What Does It Mean* and *The Chemical Elements*, students unscramble and fill in the missing letters of scientific terms. In *Scientists Say*, students learn about famous scientists by completing short quotations. (Grades 8 and above.)
Edupro. *Disk or cassette, Atari 400, 800 (24K disk, 16K cassette); joysticks: $24.95; disk: $19.95, cassette.* (NP)

3.55 **Science: Volume 2— Biology/Physics**
These science simulations are designed to provide supplementary activities for the science classroom. Biology topics include cell membrane diffusion and environmental effects of pesticides. Physics topics include momentum and kinetic energy. Math concepts include arc tangents, which

are presented in two programs simulating missile positions on a coordinate system. (Grades 7 and above.)
Minnesota Educational Computing Consortium. *Disk; Apple II series (48K): $38.00.* (NP)

3.56 Science: Volume 3—Earth/Life Science
Several science programs appropriate for earth science and life science classes are contained in this collection. *Fish* is a tutorial on blood circulation in animals with two-chambered hearts; *Minerals* is a computerized key to 29 common minerals; *Odell Lake* and *Odell Woods* are food chain simulations; *Quakes* helps to determine epicenters of earthquakes; and *Ursa* displays five major constellations in relationship to time. (Grades 7 and above.)
Minnesota Educational Computing Consortium. *Disk; Apple II series (48K): $36.00.* (NP)

3.57 Senses
Provides practice in determining which of the five senses would be used in a given situation. (Grades 4–6.)
Robbinsdale Computer Project. *Disk or cassette; Commodore PET (8K): $9.95.* (P)

3.58 Skeletal/Muscular and Circulatory Systems
This three-subject, 12-lesson module provides practice in identifying the parts, terms and functions of the skeletal/muscular and circulatory systems. It includes a summary test and vocabulary review. (Grades 5 and above.)
Centurion Industries, Inc. *ROM cartridge; Versator Educational Computer (48K): $59.50.* (P)

3.59 Teeth: Animal Skulls And Human Teeth
An introduction to the three types of teeth, with emphasis on proper dental care. Includes study cards and diagrams. (Grades 4–7.)
Spectrum Software. *Disk or cassette; Apple II series (48K); TRS-80 I, III (48K): $38.00.* (NP)

3.60 Urinary and Glandular Systems
This three-subject, 12-lesson program provides practice in identifying the parts, terms and functions of the urinary and glandular systems. It includes a summary test and vocabulary review. (Grades 5 and above.)
Centurion Industries, Inc. *ROM cartridge; Versator Educational Computer (48K): $59.59.* (P)

Chemistry

3.61 Chem Lab Simulation #3
Simulations to demonstrate Hess's law of heat reaction. Students carry out experiments using simulated calorimeter. (Grades 9 and above.)
Conduit. *Disk; Apple II series (48K): $80.00.* (NP)

3.62 Chem Lab Simulation #4
Two experiments in thermodynamics help students to find the temperature at which an unknown liquid vaporizes and to figure the enthalpy, entropy and free energy of an equilibrium reaction. (Grades 9 and above.)
Conduit. *Disk; Apple II series (48K): $80.00.* (NP)

3.63 Chemical Formulas
Names compounds using IU-PAC rules pertaining to multivalent ions. A review of the rules with sample problems is provided. Students are given three attempts to correctly write the corresponding formula before the correct answer is provided. (Grade 9.)
Micrograms, Inc. *Disk or cassette; Commodore PET (16K): $12.95.* (NP)

3.64 Chemical Nomenclature
Formulas for chemical compounds are presented and students are required to name the compounds correctly. (Grade 9.)
Micrograms, Inc. *Disk or cassette; Commodore PET (16K): $12.95.* (NP)

3.65 Chemistry Crossword
The first-year chemistry student is given an opportunity to test his or her knowledge of approximately 50 words and definitions basic to high school chemistry courses in this crossword-puzzle format. Words such as *alloy, calorie, entropy, fission, ion, isotope, oxide, precipitate* and *solute* are included. (Grades 9 and above.)
Micrograms, Inc. *Disk or cassette; Commodore 64 (16K): $14.95; Commodore PET (16K): $12.95.* (NP)

3.66 Chemistry Simulations
This set of chemistry programs presents high-resolution animated graphics lab simulations that have been extensively field-tested. The simulations provide randomly generated initial values to ensure that the experiments can be used over and over without arriving at the same results each time. (Grades 9 and above.)
Aquarius. *Two disks; Apple II series (48K): $55.00 per set; $29.95 per lesson disk.* (P)

3.67 Chemistry—The Gas Laws
All possible derivations of six basic equations relating to the gas laws are covered. Students can choose to work with a specific equation or have it selected randomly. Grading system and teacher's guide included. (Grades 9–12.)
Concept Educational Software. *Disk or cassette; TRS-80 III, 4 (16K): $30.00.* (P)

3.68 Dilute
A student-interactive simulation that mimics a microbial dilution series. Students master concepts related to concentration, dilution and bacterial colonies while learning about sterile technique, titer and pipetting. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $70.00.* (NP)

3.69 Enzkin Apple: Enzyme Kinetics
Enables students to answer for themselves some of the fundamental questions of enzyme kinetics. The program introduces students to such complex situations as substrate inhibition, cooperativity and the influence of the cofactor. (Grades 9 and above.)
Conduit. *Disk; Apple II series (48K): $40.00.* (NP)

3.70 Enzyme
A student-interactive simulation that studies an application of the lock-and-key model of enzyme action. Students develop an understanding of enzyme regulation of the chemical activities of organisms. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $70.00.* (NP)

3.71 Haber Apple: Ammonia Synthesis
This simulation helps students study the production of ammonia by the Haber process. Investigations included in the program are followed by questions to bring out important

points of the chemistry involved. (Grades 9 and above.)
Conduit. *Disk; Apple II series (48K): $40.00.* (NP)

3.72 The Incredible Laboratory: Strategies in Problem Solving

Students choose and mix "crazy chemicals" creating a monster. Each chemical produces a specific feature of the monster. The student must discover each chemical's effect and predict the monster's make-up to graduate to "scientist." Includes varying difficulty levels and competitive game option. Comes with guide. (Grades 3 and above.)
Sunburst Communications. *Disk and backup, Apple II series (48K); Atari 800, 800XL, 1200XL, 1400XL, 1450XL (48K): $49.00.* (P)

3.73 Introduction to Chemistry

Intended as a supplement to an introductory course. Simulated experiments develop basic concepts, problem sets provide practice and diagnostic feedback is provided for errors. Program covers periodic table, nomenclature, atomic weight and structure, etc. (Grades 10–12.)
COMPress. *Seven disks, Apple II series (48K): $340.00 per set; $60.00 per disk.* (P)

3.74 Matter

Explains matter, its forms and properties. A discussion of molecules is emphasized. (Grade 5.)
Right On Programs. *Disk; Apple II series (48K): $18.00. Disk or cassette; Commodore PET, 64 (32K): $18.00.* (NP)

3.75 Molecular Animation

Displays 20 common molecules. Contains instructions for building your own molecules of up to 60 atoms. Molecules are rotated through all three axes and in both directions. Enlarge and reduce, pause, and other commands. (Grades 10–12.)
COMPress. *Disk; Apple II series (48K): $75.00.* (P)

3.76 Periodic Quiz

Quizzes the student's knowledge of and ability to use the periodic table of elements. A periodic table should be available for reference during the program. (Grade 9.)
Micrograms, Inc. *Disk or cassette; Commodore PET (16K): $12.95.* (NP)

3.77 Structure of Matter

A courseware package designed for any science curriculum that includes study of the molecular structure of matter. Animation and simulations illustrate atomic configuration, valence, bonding and structural drawings. (Grades 8 and above.)
Classroom Consortia Media, Inc. *Disk; IBM PC/XT (128K): $69.95.* (NP)

3.78 Symbols to Moles

This program enables students to practice using symbols and valences, writing equations and doing mole concept calculations. (Grades 9 and above.)
Scott, Foresman and Company. *Disk and backup; Apple II series (48K): $59.95.* (NP)

3.79 Titration

This simulated lab experiment helps to conserve chemicals and laboratory preparation time while it provides students with training in titrating a given volume of hydrochloric acid using a known concentration of sodium hydroxide. The student is asked to calculate the molarity of the hydrochloric acid solution. The calculated molarity is compared to the actual molarity and the percentage of error is given. (Grade 9.)
Micrograms, Inc. *Disk or cassette; Commodore 64 (16K): $14.95; Commodore PET (16K): $12.95.* (NP)

3.80 Titration Lab

A program that covers molarity, pH, scientific notation, acid-base neutralization and titration principles. An interactive lab simulation is included. (Grades 7 and above.)
Educational Materials & Equipment Company. *Disk; TRS-80 III, 4 (48K): $45.00.* (P)

3.81 Writing Chemical Formulas

Designed to give students practice in writing chemical formulas from a possible base of more than 120 different compounds that are randomly chosen. If the student is unable to write the correct formula, the program guides the student through the process of filling out a chart on the screen, explaining oxidation states and the procedure used for balancing positive and negative charges. (Grades 7 and above.)
Microcomputer Workshops Corporation. *Disk; Apple II series (48K): $24.95.* (P)

Earth Sciences

3.82 Archaeology Set

Part of the *Search Series*. A simulation that challenges students with the task of excavating a historic colonial site. (Grades 5–9.)
McGraw-Hill/Webster Division. *Disk; Apple II series (48K); TRS-80 III, 4 (48K): $180.00.* (P)

3.83 AtariLab Science Series Starter Set

A modular system that allows students to use the computer to collect, analyze and display temperature data. Includes step-by-step instructions, examples of how to program experiments, an *AtariLab* interface and a temperature sensor. (Grades 3–9.)
Atari, Inc./Atari Learning Systems. *Cartridge; Atari 400, 800, 1200 (16K–48K): $89.95.* (NP)

3.84 The Earth and Its Composition

A discussion of the basic components that make up the earth: water, mountains, air, volcanoes and so on. Formation and erosion are also discussed. (Grade 3.)
Right On Programs. *Disk; Apple II series (48K): $18.00. Disk or cassette; Commodore 64, PET (32K): $18.00.* (NP)

3.85 Earthquakes/ Latitude-Longitude

Hands-on experience in plotting earthquakes and latitude-longitude lines is provided in this earth science program. The package includes high-resolution graphics, detailed teacher's guide and suggested activities. Instructions for updating seismic data are included. (Grades 9 and above.)
Aquarius. *Disk; Apple II series (48K): $34.95.* (P)

3.86 Earth Science

Designed to help students expand their understanding of earth science concepts. Three of the programs, *Earthquakes, Solar Distance* and *Ursa Rotation*, take advantage of the computer's ability to calculate mathematical relationships, such as seismic waves or interplanetary distances. (Grades 5–9.)
Minnesota Educational Computing Consortium. *Disk; Atari 400, 800 (48K): $35.00.* (NP)

3.87 Earth Science

A practical approach to earth science, explaining the effects of nature on the world and our lives. Computer text and graphics. (Grades 3–7.)

Orange Cherry Media. *Two disks; Apple II series (48K): $67.00. Two disks or four cassettes; Commodore PET (16K); TRS-80 I, III, 4 (16K): disks, $67.00; cassettes, $56.00 or $15.00 each.* (NP)

3.88 Geography Set
Part of the *Search Series*. A simulation in which groups of students use the sun, wind, stars, temperature and ocean depth to navigate ancient ships. (Grades 5–9.)
McGraw-Hill/Webster Division. *Disk; Apple II series (48K); TRS-80 III, 4 (48K): $180.00.* (P)

3.89 Geology Set
Part of the *Search Series*. A simulation in which students run oil exploration companies using data about rocks, fossils and underground structures. (Grades 5–9.)
McGraw-Hill/Webster Division. *Disk; Apple II series (48K); TRS-80 III, 4 (48K): $180.00.* (P)

3.90 Home Automatic Weather Station (HAWS)
HAWS combines a high-quality sensor for measuring temperature, barometric pressure, relative humidity and dewpoint with a ten-program software package for monitoring, forecasting and learning about the weather. (Grades 5 and above.)
Vaisala, Inc. *Disk or cassette; VIC 20 (5K); Commodore 64 (64K): $199.95.* (NP)

3.91 The Rock Cycle
A geology program that includes a subject lesson, lab experiments and a teacher-generated test unit. The program contains extensive color graphics. (Grades 7–12.)
Educational Computing Systems, Inc. *Disk; Apple II series (48K): $29.95.* (NP)

3.92 Rocks: Properties and Uses of Minerals
Four lessons that introduce students to the properties and uses of rocks. The program asks questions that help users identify rocks. (Grades 3–6.)
Spectrum Software. *Disk or cassette; Apple II series (48K); TRS-80 I, III (32K): $18.00 (with 18 rocks, storage box, streak plate, test squares and rock labels: $35.00).* (NP)

3.93 The Skies Above/ The Waters Below
Colorful graphic simulations depict a series of voyages ranging from the planets and stars of outer space to the waterways of earth. Students learn basic facts and vocabulary about the areas. (Grades 7 and above.)
Aquarius. *Four disks, Apple II series (48K): $115.00 per set; $29.95 per lesson disk.* (P)

3.94 Thermometer
Displays a thermometer on the computer screen and asks the student to enter its reading. Gives interpretation if desired. (Grades 6–9.)
Computer Courseware Company. *Disk or cassette; Apple II series (48K); TRS-80 I, III, 4 (32K or 16K); VIC 20 (5K); Commodore 64 (64K): $15.00.* (NP)

3.95 Time and Seasons
Designed to develop an understanding of how time is measured and regulated on earth, and the relationships of seasons and climate between the Northern and Southern hemispheres. (Grades 7–9.)
Rand McNally & Company. *Two disks; Apple II series (48K): $111.00. Three disks; Atari 800 (48K): $111.00.* (P)

3.96 Volcanoes
An earth science simulation game for teams. Each team is assigned a province and a budget. The object is to predict volcanic activity accurately through scientific investigations, while staying within the budget. Three skill levels. (Grades 7 and above.)
Earthware. *Two disks; Apple II series (48K): $49.50.* (P)

3.97 The Water Cycle
A meteorological unit containing lab experiments, color graphics and a teacher's manual. (Grades 7–12.)
Educational Computing Systems, Inc. *Disk; Apple II series (48K) $29.95.* (NP)

3.98 Weather
Teaches elementary meteorology, including standard weather symbols and locating fronts on a weather chart. (Grades 9 and above.)
Scott, Foresman and Company. *Disk and backup; Apple II series (48K): $59.95.* (NP)

3.99 The Weather Science Set
An examination of the major factors that affect the climate, as well as the vocabulary of weather observation and the instruments that trace weather patterns. (Grades 3–8.)
Orange Cherry Media. *Disk, Apple II series (48K): $34.00. Disk or two cassettes; Commodore PET (16K), TRS-80 I, III, 4 (16K); Atari 400, 800, 1200 (24K or 16K): disk, $34.00; cassettes, $28.00 or $15.00 each.* (NP)

3.100 Word Clock
Shows how the world's movement causes day and night and changes of season. Shows the planets' relationship to the sun and to each other. (Grades 8–12.)
COMPress. *Disk; Apple II series (48K): $40.00.* (P)

Products of related interest have been listed in other sections of this directory. For other materials pertaining to Earth Sciences, also see the following entries: 3.56, 3.115, 3.118.

Ecology and Environmental Studies

3.101 Acid Rain
A tutorial that uses simulation to explore the relationship between the generation of electrical power and the deterioration of the aquatic environment. Suggests additional activities. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K): $70.00.* (NP)

3.102 Air Pollution: Introduction to Computer Models
A simulation of carbon monoxide pollution in an urban environment. Students manipulate variables and are shown computer modeling and development. Student lab booklets accompany the program. (Grades 7 and above.)
Educational Materials & Equipment Company. *Disk; Apple II series (48K): $37.00; TRS-80 I, III, 4 (48K): $38.50.* (P)

3.103 Balance
A student-interactive simulation that explores the interrelated variables affecting predator/prey relationships. Students develop scientific problem-solving, tabulation, graphing and interpretation skills. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K), TRS-80 I, III (32K), IBM PC (64K): $70.00.* (NP)

3.104 Energy House
A simulation/problem-solving program that allows students to travel through two to seven rooms in a house looking for ways to save energy. The stu-

dent enters commands to correct energy wasters within the given time limit. Correct responses to problems posed by the computer result in an increase in energy efficiency that is registered on the "thermometer" on the screen that keeps track of the score. Success is stated in terms of energy saved. (Grades 4–8.)
Total Information Educational Systems. *Disk and backup; Apple II series (48K); printer, color monitor: $49.95.* (P)

3.105 Energy Set
Part of the *Search Series*. A simulation in which students must allocate resources, plan for the future, cope with new developments and balance the advantages and disadvantages of each type of fuel. (Grades 5–9.)
McGraw-Hill/Webster Division. *Disk; Apple II series (48K); TRS-80 III, 4 (48K): $180.00.* (P)

3.106 Galactic Prospector
In this simulation the user becomes the chief scientist for the Energy Information Center, evaluating all relevant data to determine what sources of energy should be developed, how, and in what quantities. (Grades 8 and above.)
Walt Disney Personal Computer Software. *Disk; Apple II series (48K); Atari 800 (32K): $75.00.* (P)

3.107 Heatloss
Students use support-manual data sheets to collect and compile observations and measurements about energy loss in their own homes. This data is processed by the *Heatloss* program and a printout of the results is made. The printout identifies problem areas and gives estimates of what the loss of energy is costing in dollars. (Grades 7 and above.)
Minnesota Educational Computing Consortium. *Disk; Apple II series (48K): $38.00.* (NP)

3.108 Home Energy Conservation
This program enables users to determine household fuel, hot water and electricity consumption. Conservation is explored through double glazing, insulation, weather stripping and efficient appliances. (Grades 7 and above.)
Educational Materials & Equipment Company. *Disk; Apple II series (48K): $35.00; TRS-80 I, III, 4 (48K): $37.00.* (P)

3.109 Mangry
An interactive program that permits students to explore human cultural types, their energy needs, their environmental impacts and the productivities of natural and man-made ecosystems. Data analysis and interpretation is featured. (Grades 9 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $60.00.* (NP)

3.110 Niche
An interactive program that uses a stimulating game format to explore the concept of the ecological niche. Students must attempt to correctly place one of five organisms in its proper ecological niche by specifying the environment, range and competitor for the organism. (Grades 9 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $60.00.* (NP)

3.111 Pollute
A student-interactive simulation that examines the impact of various pollutants on typical bodies of water. This program would also be an appropriate unit for lessons in biology or environmental studies classes. (Grades 8 and above.)
Diversified Educational Enterprises, Inc. *Disk; Apple II series (48K); TRS-80 I, III (32K); IBM PC (64K): $70.00.* (NP)

3.112 Sunstart
Uses pictures and dynamic graphics to present the concepts of using solar energy for home heating, hot water heating, electricity, and so on. (Grades 1–6.)
Solartek. *Disk, Apple II series (48K), TRS-80 I, III, 4 (48K); IBM PC (48K) $49.00.* (P)

3.113 Water Pollution
The impact of pollution on aquatic life. An interactive simulation enables students to solve realistic problems by manipulating variables. Accompanying student lab booklets. (Grades 7 and above.)
Educational Materials & Equipment Company. *Disk, Apple II series (48K) $29.95; TRS-80 I, III, 4 (48K): $31.75.* (P)

General Science

3.114 Characteristics Of a Scientist
Introduces the student to scientific methods through a series of thought-provoking puzzles, quizzes, observations and tricks played by the computer. High-resolution color graphics and effective questioning techniques are designed to maintain high interest. (Grades 6–12.)
Cygnus Software. *Disk; Apple II series (48K): $39.00.* (P)

3.115 Create-a-Test Question Files
To be used with the *Create-a-Test* program. Each disk contains 450 questions. The 21 available disks cover chemistry, biology, physical science, physics, geography and botany. (Grades 11 and above.)
Cross Educational Software. *21 disks; Apple II series (48K): per disk, $49.95.* (P)

3.116 Micrometer
Students master the skills required to read and set a micrometer. From a display on the screen, students move the micrometer barrel to the correct setting for a previously assigned decimal number. (Grades 5 and above.)
School & Home CourseWare, Inc. *Disk or cassette; Apple II series (8K); Commodore 64, PET (8K), TRS-80 I, III (8K); Atari 400, 800, 1200 (8K): $29.95.* (NP)

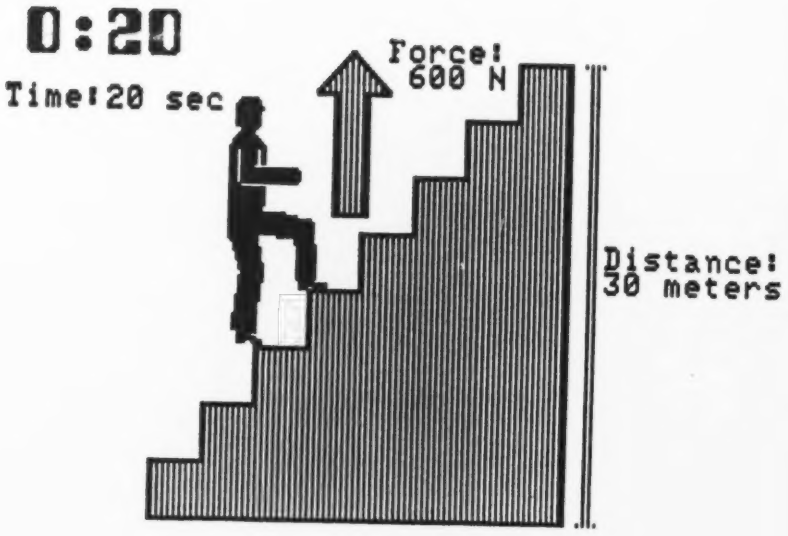
3.117 Microscope 1
A graphic presentation teaches the parts of the microscope. (Grades 7 and above.)
Robbinsdale Computer Project. *Disk or cassette; Commodore PET (16K): $9.95.* (P)

3.118 Think or Swim
It takes two players to row the boat safely to shore, depending on the number of correct answers given to true/false and yes/no questions about dinosaurs, plants, invertebrates, pollution, weather, and conservation of energy. (Grades 3–8.)
Micrograms, Inc. *Disk or cassette Commodore 64 (16K): $14.95, Commodore PET (16K): $12.95.* (NP)

3.119 Word Tutor
Student or teacher enters word and its definition. Student then has choice of drills on spelling, matching items, completion, multiple-choice or true/false. Program includes science word list. Drills in progress can be saved. (All grades.)

Indiana Biolab. *Disk or cassette; TRS-80 III, 4 (16K): $19.99.* (P)

3.120 **Zandar**
Players follow a wizard as they learn to form and test hypotheses. The program begins with the steps of the hypothesis-testing strategy and moves on to gathering information, forming hypotheses and testing and altering them as needed. (Grades K–6.)
Society for Visual Education, Inc.
Two disks and backups; Apple II series (48K): $120.00. (NP)



B

Useful Addresses and Sources of Assistance

Given the rapidly evolving condition of microcomputer hardware and software available for teaching science, access to sources of current information may be the most critical part of preparing and maintaining an effective program. Below are addresses and brief descriptions of sources of potential assistance. These are current as of Spring, 1984, and are mostly taken from the *Classroom Computer Learning DIRECTOR OF EDUCATIONAL COMPUTING RESOURCES* for 1983-84 ($9.95 from *Classroom Computer Learning*, 19 Davis Dr., Belmont, CA 94002). Resources shown here are for the State of Texas.

1. Keith Mitchell, Educational Specialist
   Texas Education Agency
   201 E. 11th Street
   Austin, Texas 78701
   (512) 475-2479

   Keith is a science teacher now completing a doctorate in science education at the University of Texas. He is familiar with most applications and software at the secondary level. He is completing work on an educational network to provide current information on-line through microcomputers and phone systems to each of the 20 Regional Service Centers throughout the State. He also assisted in writing this training module. Keith is a walking encyclopedia of information on teaching science with computers.

2. Region IV Educational Service Center (ESC)
   Vicki S. Smith
   Coordinator for Computer-Based Instruction
   P.O. Box 863
   Houston, TX 77001
   (713) 462-7708

   Although each of the twenty Educational Service Centers in Texas provides technical assistance and teacher training, the Region IV ESC in Houston is the main center, and is presently coordinating a statewide microcomputer courseware evaluation project. Approximately 1500 courseware items for Apple, Commodore PET and Radio Shack TRS-80 microcomputers have been evaluated thus far. This evaluation information is available on a retrievable data base through each of the 20 state Education Service Centers.

3. Texas Computer Education Association (TCEA)
Vicki Smith, President
P.O. Box 2573
Austin, TX 78768

TCEA provides information on current trends in the field of computer education through its newsletter, computer workshops and conferences. Its annual conference is held in Austin in March, and attracts most major publishers and software distributors. This is a convenient way to assess science software without having to order or purchase anything. The conference proceedings describe ways that teachers are using computers in each subject matter area.

* * * * *

The following magazines are written specifically for users of one brand of microcomputer. Not all are limited to classroom applications, but each should be helpful for users of featured type of computer. Vendors who sell software for that machine will, of course, advertise in the magazine for that machine's users. Only one magazine is listed for each of the common types of microcomputer in Texas classrooms. Many more are described in the CCL *DIRECTORY* cited previously.

1. *Antic, The Atari Resource*
Antic Publishing
600 18th st.
San Francisco, CA 94107
(415) 863-2340
$2.50 / issue; $24.00 / 12 issues

This monthly publication's programs can be copied free without permission. Covers educational topics, and includes user group and new product information, help for beginners and programming tips.

2. *In-Cider* for users of Apple computers
Green Publications Group
80 Pine Street
Peterborough, NH 03458
(603) 924-9471
$25.00 / 12 issues

This magazine contains program listings, book reviews and software reviews related to all users of Apple equipment. Regular columns are devoted to Applesoft BASIC programs, "Hints and Techniques", "The Apple Clinic" (repairs and maintainence), etc. New products for the Apple are also listed.

3. *Basic Computing*
3838 S. Warner Street
Tacoma, WA 98409
(206) 475-2219
$3.00 / issue; $19.97 / 12 issues

This magazine is subtitled "The TRS-80 User Journal", and is for users of that machine.

4. *Commodore: The Microcomputer Magazine*
Commodore Computers
Educational Marketing Div.
1200 Wilson Dr.
West Chester, PA 19380
(215) 431-9100
$2.50 / issue; $15.00 / 6 issues

The May 1983 issue of this new bimonthly focused on education, and provided ideas for making sound decisions about creating and implementing a school computer program.

5. *99'er Home Computer Magazine*
Suite 250
1500 Valley River Dr.
Eugene, OR 97405
(503) 485-8796
$3.50 / issue; $25.00 / 12 issues

This magazine deals with business, game and educational uses of the TI home computer. Includes program listings and tutorials for general to technical readers. Includes Logo applications in each issue.

6. *PC: The Independent Guide to IBM Personal Computers*
1 Park Ave.
New York, NY 10016
(212) 725-4694
$2.95 / issue; $27.00 / 12 issues

This non-technical monthly magazine presents articles on issues and educational applications of the IBM PC. Reviews of software and reference books are included regularly.

7. *Timex Sinclair User*
49 La Salle Ave.
Buffalo, NY 14214
(716) 834-1972
$2.95 / issue; $29.95 / 12 issues

Approximately one-fourth of this monthly publication is related to classroom uses of the Sinclair computers. Articles geared for a variety of experience levels. Contains regular equipment and software reviews.

* * * * *

The American Chemical Society Division of Chemical Education's Task Force on Computers in Chemical Education has produced a list of science software sources. Below are listed those which produce courseware for the secondary school level, with notations of hardware for which it is written. Note that these sources usually have a variety of science software, and are not limited to chemistry. This list is supplied by G. Scott Owen, Chairman, Dept. of Chemistry, Atlanta University, Atlanta, GA 30314

1. Avant-Garde Creations
Dept. E, P.O. Box 30160
Eugene, OR 97403
Apple

2. Commodore Business Machines
3330 Scott
Santa Clara, CA 95054
Pet

3. Dr. Daley
Water Street
Darby, MT 59829
Apple, Pet

4. Educational Materials and Equipment Co.
P.O. Box 17
Pelham, NY 10803
Apple

5. G-2 Compuscience
P.O. Box 683
Mauldin, SC 29662
Apple

6. High Technology, Inc.
P.O. Box 14665
Oklahoma City, OK 73113
Apple

7. J & S Software
140 Reid Avenue
Port Washington, NY 11050
Apple, TRS-80

8. MECC (Minnesota Educational Computing Consortium
2520 Broadway Drive
Minneapolis, MN 55113
Apple

9. Mentor Software
515 Park St.
Anoka, MN 55303
Apple

10. Merlan Scientific Ltd.
247 Armstrong Avenue
Georgetwon, Ontario, Canada L7G 4X6
Pet

11. Micro Learningware
P.O. Box 2134
North Mankato, MN 56001
TRS-80

12. Microphys
2048 Ford Street
Brooklyn, NY 11229
Apple, Pet

13. Milne PRess
P.O. Box 1246
Carmel Valley, CA 93924
Apple, Pet, TRS-80

14. Programs for Learning, Inc.
P.O. Box 954
New Milford, CT 06776
Apple, Pet, TRS-80

15. Project SERAPHIM/Computer Series
Journal of Chemical Education
J.W. Moore and J.J. Lagowski
Dept. of Chemistry
Eastern Michigan University
Ypsilanti, MI 48197
Apple, Pet, TRS-80, others

16. TIES
1925 W. County Road B2
St. Paul, MN 55113
Apple

17. John Wiley and Sons, Inc.
Dept. 1275
605 Third Ave.
New York, NY 10158
Apple, Pet, TRS-80

* * * * *

Addresses of Other Secondary Science Software Suppliers

1. Applied Microsystems, Inc.
P.O. Box 832
Roswell, GA 30077

2. Aquarius
P.O. Box 128
Indian Rocks Beach, Fl 33535

3. Atari Learning Systems
1399 Moffett Park Dr.
Sunnyvale, CA 94088

4. BrainBank, Inc.
200 Fifth Ave.
New York, NY 10001

5. BSCS Software
Attn: James D. Ellis
The Colorado College
Colorado Springs, CO 80903
1-303-473-2233

6. Centurion Industries, Inc.
167 Constitution Dr.
Menlo Park, CA 94025

7. Classroom Consortia Media, Inc.
57 Bay St.
Staten Island, NY 10301

8. COMPress
P.O. Box 102
Wentworth, NH 03282

9. Computer Applications Tomorrow
P.O. Box 605
Birmingham, MI 48012

10. Computer Courseware Company
2118 S. Grand Ave.
Santa Ana, CA 92705

11. Concept Educational Software
P.O. Box 6184
Allentown, Pa 18001

12. Conduit
The University of Iowa
P.O. Box 388
Iowa City, IA 52244

13. Control Data Corporation
8100 34th Ave. South
Minneapolis, MN 55440

14. Cross Educational Software
1802 N. Trenton St.
P.O. Box 1536
Ruston, LA 71270

15. Cygnus Software
8002 E. Culver
Mesa, AZ 85207

16. Diversified Educational Enterprises, Inc.
725 Main St.
Lafayette, IN 47906

17. Earthware
2386 Spring Blvd.
P.O. Box 30039
Eugene, OR 97403

18. Educational Materials & Equipment Co.
P.O. Box 17
Pelham, NY 10803

19. Edupro
445 Charleston Rd.
Palo Alto, CA 84306

20. EduTech
634 Commonwealth AVe.
Newton Centre, MA 02159

21. EMC Publishing
300 York Ave.
Saint Paul, MN 55101

22. HRM Software
175 Tompkins AVe.
Pleasantville, NY 10570
1-800-431-2050

23. Idaho Software Producers
1863 Bitterroot Dr.
Twin Falls, ID 83301

24. McGraw-Hill/Webster Division
1221 Avenue of the Americas
New York, NY 10020

25. Micro Power and LIght Company
12820 Hillcrest Rd. #219
Dallas, TX 75230

26. Microcomputer Workshops Corporation
225 Westchester Ave.
Port Chester, NY 10573

27. Micrograms, Inc.
P.O. Box 2146
Loves Park, IL 61130

28. Monument Computer Services
P.O. Box 603
Joshua Tree, CA 92252

29. Professional Computerware
P.O. Box 409
Morganton, GA 30560

30. Rand McNally & Company
P.O. Box 7600
Chicago, IL 60680

31. School and Home CourseWare, Inc.
1341 Bulldog Ln., Suite C
Fresno, CA 93710

32. Scott, Foresman and Company
1900 E. Lake Ave.
Glenview, IL 60025

33. Sliwa Enterprises, Inc.
2360-J George Washington Hwy.
Yorktown, VA 23692

34. Softbyte Computing
Box 217
Wallingford, CT 06942

35. Starbound Software
P.O. Box 1123
Solvang, CA 93463

36. Sunburst Communications
39 Washington Ave., Rm CL
Pleasantville, NY 10570

37. Tab Books, Inc.
Monterey Ln
Blue Ridge Summit, PA 17214

38. Vaisala, Inc.
2 Tower Office Park
Woburn, MA 01801

39. Vernier Software
2920 SW 89th St.
Portland, OR 97225
1-503-297-5317

40. Walt Disney Personal Computer Software
500 S. Buena Vista St.
Burbank, CA 91521

41. Zephyr Services
306 S. Homewood Ave.
Pittsburg, PA 15208

* * * * *

This Certifies that

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HAS SUCCESSFULLY COMPLETED

MICROCOMPUTERS
IN
SECONDARY SCIENCE INSTRUCTION

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PRESENTER

EDUCATION SERVICE CENTER

DREYFUS DISK #1

*A	014	ACID STRENGTH
*A	030	AN EQUILIBRIUM SIMULATION
*A	021	BALLOON
*B	004	CHEMTITLE
*A	003	HELLO
*A	029	HELLO2
*A	024	LAB CALC--BOYLE'S LAW
*B	014	MC.TITLE
*A	009	MOLE CALCULATIONS
*A	033	MOLE CALCS2
T	002	NAMES
*B	011	Q1.1
*B	013	Q1.2
*B	011	Q1.3
*B	012	Q2.1
*B	011	Q2.2
*B	015	Q2.3
*B	013	Q3.1
*B	010	Q3.2
*B	013	Q3.3
*B	017	QM3.OBJ
*A	013	QUIZ ON MOLAR MASSES
*B	022	RADIOACTIVE DECAY.OBJ
*B	017	RUNTIME
*B	003	SCRUNCH
*A	019	SIGNIFICANT FIGURE DRILL
*A	014	THE MOLE GAME--PART I
*A	012	THE MOLE GAME--PART II
*A	015	THE MOLE GAME--PART III
*A	011	VALENCE DRILL
*A	002	PIC LOOKER

DREYFUS DISK #2

*A	025	HELLO
*B	034	NETWORK TITLE
*B	034	MAIN MENU
*A	017	CANAL1
*A	049	CANAL2
*A	043	CANAL3
*A	003	MS
*A	012	M12
*B	006	CHAR2
*A	003	RAST LOGO
*B	014	RAST TABLES
*A	052	RAST
*A	072	THERMO
*A	009	KINETICS.START
*A	052	KINETICS.REVISED
*B	002	LOMEN:
*B	006	CHR SET*
*B	003	CHR GEN
*B	006	CHR SET

Dreyfus Disk #4

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*A   015  HELLO
*A   018  TITRATION
*A   015  CHEMISTRY LAB
*B   012  MAIN MENU
*B   007  PRINTABLE ASCII
 T   004  PRECIP DATA
*B   008  ASCII +
*A   011  GEN.PRECIP DATA
*A   024  PRECIPITATION GAME
*B   008  SCRIPT
*B   005  SKYWRITER.)BJ9200
*B   002  LOMEM:
*A   025  CHEMCRUNCH
*A   002  CHEMDEM
*A   017  CHLORINATION OF METHANE ANIMA
*B   011  CHEMLTR1
*B   062  PRECIP.OBJ
*A   004  PRECIPITATION TITLE
*A   005  ANIMATION TITLE
*B   032  SCRUNCHED PIC.PIMA
*B   004  NETWORK TITLE
*B   003  SCRUNCH
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Vernier "Ray Tracer"

```
 A   003  HELLO
*B   034  RAY TRACER LOGO
*B   017  RUNTIME
*B   064  RAY TRACER.OBJ
*B   004  HGR LETTERS
 A   002  HELLO.B
*T   002  RT
*A   073  RAY TRACER
*T   002  RAINBOW
*T   002  MIRRORO-SPHERICAL ABERRATION
*T   002  MIRROR-IMAGE
*T   002  TOTAL INTERNAL REFLECTION
*T   002  LENS-IMAGE
*T   002  LENS-SPHERICAL ABERRATION
*T   002  LENS-CHROMATIC ABERRATION
*T   002  COMPOUND LENS
*A   073  RAY TRACER (BACKUP)
```

Vernier "Graphical Analysis II"

```
*A    003  HELLO
*B    034  GRAPHICAL ANALYSIS II LOGO
*A    057  GRAPHICAL ANALYSIS
*B    004  HGR LETTERS
*A    034  PRINTER
*A    011  CONTERTER
*T    002  RELOAD
*T    002  SAMPLE-FREE FALL
*T    002  SAMPLE-GALILEO
*T    003  SAMPLE-BOYLE
*T    002  SAMPLE-COULOMB
*T    002  SAMPLE-T VS H
*T    002  SAMPLE-T VS D
*T    002  SAMPLE-DECAY
*T    002  SAMPLE-WIRE
*T    002  SAMPLE-POSTAL RATES SINCE 1958
*T    002  SAMPLE-POSTAL RATES SINCE 1885
*T    002  SAMPLE-GRAINS
*T    002  SAMPLE-RINGS
*T    002  SAMPLE-RINGS2
*T    004  SAMPLE-PENDULUM
A     057  GRAPHICAL ANALYSIS (BACKUP)
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*A   018  HELLO
*A   006  READER
*A   029  C
*A   060  G
*T   002  CLASS NAMES
 T   008  MATH 11
 T   007  CHEM 1
*T   018  PHOTOSYNTHESIS1
*A   021  B
*T   019  PHOTOSYNTHESIS
*A   006  SCORE
 T   002  PHOTO2
*A   002  RUN HELLO FOR DEMONSTRATIONS
 T   002  RED
*B   002  MOVE
*A   006  RECORD
*B   002  PACK
*B   021  PIC.INTRO
*B   017  P1
*B   018  P2
*B   017  PIC.CHEM
*B   005  PIC.NEW1
*B   006  EQUATIONS.NEW
*B   007  PIC.NEW2
*B   020  PIC.SOL
*A   025  P
*B   005  PIC.WORD
*B   008  PIC.PHYSICS
*B   014  VOLT.PIC
*B   003  VG.S
 T   002  NEW
 B   034  VG.P2
*A   034  GRADES
*T   025  ANTI
 T   002  WORD
*B   014  P3
*B   002  IIE-II
*A   002  CHEMISTRY DEMO
*A   002  BIOLOGY DEMO
*A   002  GEADE BOOK DEMO
*A   002  PHYSICS DEMO
```

*A	019	KINEMATICS
*B	037	HRM.SHP
*B	034	FINAL LOGO.PIC
*A	004	HELLO
*A	004	MAIN PROGRAM
*A	007	MAINMENU
B	002	ASMSUBS.OBJO
B	002	FLASM.OBJO
*B	003	RBOOT
*A	009	LINTENSITY
*B	005	RLOAD
*B	020	FID
*R	012	HRCG
*A	020	FFUSION
*A	015	LEEQUIVALENCE
*A	011	HRATE
*A	022	RTIMES
*A	022	EVAPORATION
T	002	CALCON
*A	014	CALIBRATION
*A	023	INSOLATION
T	002	LECALIB
B	003	RTIMER.OBJO
*A	025	RHEATS,
*A	025	RRATES
*A	022	CCURVES
*A	004	SIGNON
*A	005	WEATHER

□ DRILL & PRACTICE

SIMULATION

TUTORIAL

〈 〉 LOGIC / INQUIRY

☆ PROBLEM SOLVING

BIOLOGY

CHEMISTRY

PHYSICS